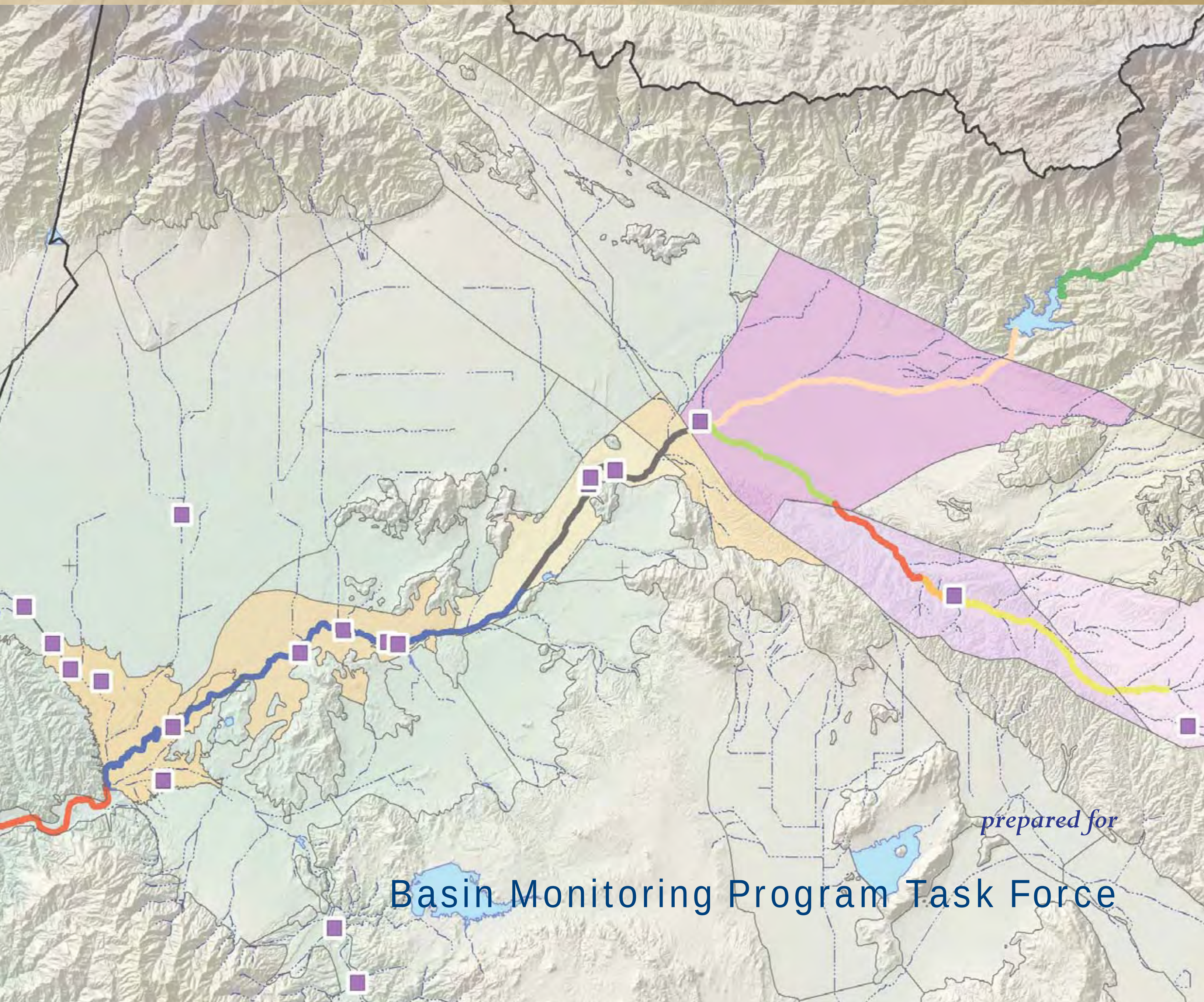
2004 Basin Plan Amendment Required Monitoring and Analyses

2008 Santa Ana River Wasteload Allocation Model Report

Final Report



prepared for

Basin Monitoring Program Task Force

May 2009

WILDERMUTH™
ENVIRONMENTAL INC.

May 13, 2009

Santa Ana Watershed Project Authority
Attention: Mr. Mark Norton
11615 Sterling Avenue
Riverside, CA 92503

Subject: Final Report - 2008 Santa Ana River Wasteload Allocation Model Report

Dear Task Force Members:

Wildermuth Environmental, Inc. (WEI) is proud to submit the *2008 Santa Ana River Wasteload Allocation Model Report* to the Basin Monitoring Program Task Force in fulfillment of our agreement (Task Order: WILD374-02). This report summarizes our efforts to update, calibrate, and apply the Wasteload Allocation Model to estimate projected TDS and Nitrate-N concentrations of the Santa Ana River recharge water and discharge at Prado Dam in accordance with the 2004 Basin Plan Amendment. The report has been vetted through the Task Force and all their comments have been included and responded to.

We have enjoyed the opportunity to work on this important project, and the staff at WEI would like to express their appreciation to all members of the Task Force for their contributions. We look forward to working with the Task Force to include the findings of this important work in the upcoming Basin Plan amendment.

Very truly yours,

Mark J. Wildermuth, PE

Chairman
Wildermuth Environmental, Inc.

Thomas D. McCarthy, PE, PG

Associate Engineer
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Jeffrey Hwang, PhD

Principal Engineer
Wildermuth Environmental, Inc.

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Prepared by

Wildermuth Environmental, Inc.

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Acronyms, Abbreviations, and Initialisms

AMC	Antecedent Moisture Condition
CBFIP	Chino Basin Facilities Improvements Program
CBWCD	Chino Basin Water Conservation District
CN	Curve Number
CWA	Clean Water Act
DEM	digital elevation model
EMWD	Eastern Municipal Water District
EVMWD	Elsinore Valley Municipal Water District
HSAs	hydrologic simulation areas
IEUA	Inland Empire Utilities Agency
JCSD	Jurupa Community Services District
MWDSC	Metropolitan Water District of Southern California
NSE	Nash-Sutcliffe Efficiency coefficient
OCSD	Orange County Sanitation District
OCWD	Orange County Water District
POTWs	Publicly-Owned Treatment Works
RCFCWCD	Riverside County Flood Control and Water Conservation District
RMSE	Root Mean Square Error
SAWPA	Santa Ana Watershed Project Authority
SBCFCD	San Bernardino County Flood Control District
SBVMWD	San Bernardino Valley Municipal Water District
SBVWCD	San Bernardino Valley Water Conservation District
SCAG	Southern California Association of Governments
SCS	Soil Conservation Service
SWMM	Storm Water Management Model
SWRCB	State Water Resource Control Board
TDS	total dissolved solids
TIN	total inorganic nitrogen
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
WEI	Wildermuth Environmental, Inc.

Acronyms, Abbreviations, and Initialisms (Continued)

WLAM	Wasteload Allocation Model
WMWD	Western Municipal Water District
YVWD	Yucaipa Valley Water District

1.1 Introduction

Under California Water Code Section 13240 et seq., each Regional Water Quality Control Board must formulate and adopt a water quality control plan (Basin Plan) for all areas within its respective region. Each Basin Plan must include:

- Beneficial uses, which are to be protected;
- Water quality objectives, which protect these uses; and
- An implementation plan to achieve those objectives.

Beneficial uses are the uses to which surface water and groundwater are or may be put, including water contact recreation; municipal, agricultural, and industrial supply; and the preservation of fish and other aquatic wildlife.

Water Code Section 13050 defines water quality objectives as "the limits or levels of water quality constituents or characteristics which are established for the reasonable protection of beneficial uses of water or the prevention of nuisance within a specific area." At a minimum, a Regional Board must consider the following factors in establishing water quality objectives:

"(a) Past, present and probable future beneficial uses of water.

(b) Environmental characteristics of the hydrographic unit under consideration, including the quality of the water available thereto.

(c) Water quality conditions that could reasonably be achieved through coordinated control of all factors which affect water quality in the area.

(d) Economic considerations

(e) The need for developing housing within the region.

(f) The need to develop and use recycled water" (Section 13241).

In addition, the existing quality of water for which the objectives are being established must be considered. Both federal and state antidegradation policies require that existing high quality waters be protected unless lowering that quality:

- Is necessary to accommodate important economic or social development
- Is consistent with the maximum benefit to the people of the sate
- Will not unreasonably affect actual or potential beneficial uses

The implementation plan required in each Basin Plan includes the control of waste discharges by the Regional Board through waste discharge requirements and/or the prescription of waste discharge prohibitions. Implementation plans must also include recommendations for actions that are not under the Regional Board's statutory authority but can be undertaken by other public or private entities. Actions may include, but are not limited to, the construction and operation of desalters, well fields designed to intercept poor quality groundwater, and groundwater recharge programs.

The Water Code states that Basin Plans must be periodically reviewed and revised. The

Federal Clean Water Act (CWA) specifies that water quality standards (beneficial uses and water quality objectives) must be reviewed at least once every three years. Basin Plan revisions may include changes to beneficial uses, water quality objectives, and implementation plans. However, state and federal policies and regulations place stringent limits on the Regional Board's discretion in making these changes:

- Beneficial Uses. For surface water, the CWA (Section 101 [a][2]) establishes the national "fishable/swimmable" goal, which states that, wherever attainable, water quality that "provides for recreation in and on the water" must be achieved. Where the Regional Board does not designate "fishable/swimmable" uses, a use attainability analysis must be performed to demonstrate that these uses are not attainable based on physical, chemical, biological, or economic factors (40 CFR 131.10[j]). These waters must be reviewed at least once every three years to determine whether conditions have changed such that "fishable/swimmable" uses should be designated. For surface waters, existing beneficial uses (as of 1975) may not be removed but must be maintained and protected (40CFR 131.10 [j][2]). The Water Code prohibits the removal of beneficial uses solely on economic grounds (Section 13241).
- Water Quality Objectives. The reduction of water quality (establishment of less stringent water quality objectives) requires a demonstration that the change is necessary to accommodate important economic or social development and is consistent with maximum benefit to the people of the state and that actual and potential beneficial uses will not be unreasonably affected. If less stringent water quality objectives are proposed on the basis that prior technical errors or insufficient information led to the development of inappropriate water quality objectives, there must be a finding that the new objectives are theoretical rather than an actual reduction of water quality. Regardless, the level of water quality necessary to protect existing beneficial uses must be maintained.
- Implementation Plans. Changes to implementation plans are appropriate and necessary as conditions in a region change and as the understanding of water quality problems and issues improves. However, the intent of an implementation plan, to meet water quality objectives, must remain unchanged.

The 1975, 1983, 1995, and 2004 Basin Plans have wasteload allocations for discharges to the Santa Ana River. Under the CWA, violations of water quality objectives must be addressed by calculating the maximum wasteloads that can be discharged to achieve and maintain compliance. The Santa Ana River Watershed Basin Plan, in its entirety, contains a wasteload allocation for the watershed through its water supply and wastewater management plans. The wasteload allocation for the Santa Ana River was developed with the Wasteload Allocation Model (WLAM). The WLAM simulates the fate and transport processes for total dissolved solids (TDS) and total inorganic nitrogen (TIN). TIN consists of the sum of ammonia, nitrite, and nitrate, expressed as nitrogen. The wasteload allocations in the 2004 Basin Plan Amendment were based on future (2010) projections of TDS and TIN. The 2008 version of the WLAM was used in this investigation to update the wasteload allocation for an upcoming basin plan amendment in either 2009 or 2010.

1.2 Summary of Prior Work

In 1995, the TIN/TDS Task Force was formed to provide oversight, supervision, funding, and approval of a study to evaluate the impacts of TIN and TDS on water resources in the Santa Ana Watershed. Members of the TIN/TDS Task Force include:

- Chino Basin Water Conservation District (CBWCD)
- Chino Basin Watermaster
- City of Colton
- City of Corona
- City of Redlands
- City of Rialto
- City of Riverside
- City of San Bernardino
- Eastern Municipal Water District (EMWD)
- Elsinore Valley Municipal Water District (EVMWD)
- Inland Empire Utilities Agency (IEUA)
- Jurupa Community Services District (JCSD)
- Metropolitan Water District of Southern California (MWDSC)
- Orange County Sanitation District (OCSD)
- Orange County Water District (OCWD)
- Regional Water Quality Control Board, Santa Ana Region (Regional Board) – Advisory Member
- Riverside-Highland Water Company
- San Bernardino Valley Municipal Water District (SBVMWD)
- San Bernardino Valley Water Conservation District (SBVWCD)
- Santa Ana Watershed Project Authority (SAWPA) – Advisory Member
- US Geological Survey (USGS) – Advisory Member
- West San Bernardino County Water District
- Yucaipa Valley Water District (YVWD)

Wildermuth Environmental, Inc. (WEI) was retained by the TIN/TDS Task Force, through a contract administered by SAWPA, to conduct scientific and engineering investigations for the TIN/TDS Study (Task Order 1998-W020-1616-03). This work is a follow up of the previous modeling conducted in 2003 to determine the wasteload allocation for the Santa Ana River. The 2003 modeling work was used to prepare the 2004 Basin Plan Amendment (Regional Board, 2004).

1.3 The Wasteload Allocation Approach

The boundary of the study area is the Santa Ana River drainage area to Prado Dam and excludes the drainage area tributary to Lake Elsinore. This study area is the minimum area necessary to estimate discharge and the associated TDS and TIN concentrations for the reaches identified in the Basin Plan. The reaches that were included in the study are Santa Ana Reaches 3 and 4 and San Timoteo Reaches 1 through 4. All Santa Ana River reaches and groundwater management zones are shown in Figure 1-1. Figure 1-2 shows the Santa Ana River reaches included in this study, discharge locations, groundwater management zones, and their associated TDS and TIN objectives. The management zones that could be influenced by the wasteload allocation include the Beaumont management zone (San Timoteo Creek Reach 4), the San Timoteo management zone (San Timoteo Creek Reaches 2 through 4), the Bunker Hill B management zone(Santa Ana River Reach 5), the Colton management zone (Santa Ana River Reach 4), the Riverside A management zone (Santa Ana River Reach 4), the Chino South management zone (Santa Ana River Reach 3), and the Orange County management zone (Santa Ana Reach 2).

In the Santa Ana River Watershed, publicly owned treatment works (POTWs) discharge to the Santa Ana River, its tributaries, or to ponds. Discharges to the river commingle with other surface discharges that consist of runoff, rising groundwater, and other POTW discharges. Seepage occurs in the streambed, reducing surface discharges and introducing POTW discharges to groundwater; and in some reaches, rising groundwater contributes to surface discharge in the river. POTW discharges to ponds discharge directly to groundwater and were therefore not included in this investigation.

Runoff from precipitation discharges across the land surface and either percolates into the ground or discharges to stream channels where it commingles with other runoff, rising groundwater, and discharges from POTWs. Runoff water contains TDS and TIN from precipitation and from *wash off* from the land surface. The *wash off* load is dependent on soils, land use, time since last significant precipitation, and non-point source management practices. Seepage in the streambed reduces surface discharge and introduces runoff to groundwater.

The characterization of TDS and TIN loads by source needs to account for climatic and seasonal variability. POTWs discharge year-round at fairly constant rates. Nonpoint sources discharge seasonally and can vary dramatically from year to year due to precipitation. Runoff, percolation of runoff, and associated TDS and TIN loading processes are sensitive to time scales and climate. The approach developed for this wasteload allocation consists of estimating the current and proposed surface water metrics based on:

- TDS and TIN concentrations that are based on an estimate of current and future levels of POTW discharges to the River
- The expectancy of nonpoint source contributions from nonpoint loading processes for several years of daily precipitation data with constant land use and water management practices

1.4 Scope of Work

The scope work developed by WEI, approved by the Task Force, and executed for the wasteload allocation consists of the following tasks:

Task 1 - Develop Calibration Hydrology and Related Data. The precipitation, stream discharge, and water quality time histories developed during last investigation were updated. Other data—such as operational information for reservoirs, new flood control or other related facilities, and new land use and drainage area information—were also collected and extended through 2007.

Task 2 - Calibrate WLAM. The data collected in Task 1 that pertain to calibration were integrated into data files used in the WLAM. This task included getting the model running (debugging) and verifying the input data. Several runs were completed to ensure that the data were correctly entered. Upon completion of QA/QC simulations, the surface water discharge model was calibrated first for the 1995 to 2006 period. At the conclusion of the hydraulic calibration, TDS and TIN were calibrated. Modeling results from the calibration period were compared to observed values for the Santa Ana River at Riverside Narrows, below Prado Dam, and other appropriate locations in the study area.

Task 3 - Develop Future Planning Scenarios for the Santa Ana River Operation. Requests for projected recycled water production, reuse, discharges to the Santa Ana River and its tributaries, and expected quality were made to each POTW. The data were reviewed, and a daily discharge schedule was developed for the 50-year planning period. Based on the discharge information provided and feedback from the Task Force, planning scenarios were developed and circulated for review.

Task 4 - Evaluate Wasteload Allocation for Selected Planning Scenarios. In this task, the updated WLAM was converted to simulate each planning scenario. Upon completion of the simulations, the results of each modeling scenario were summarized.

Task 5 - Prepare Report. A draft report was be prepared and submitted to the Task Force for review and comment.

1.5 Report Organization

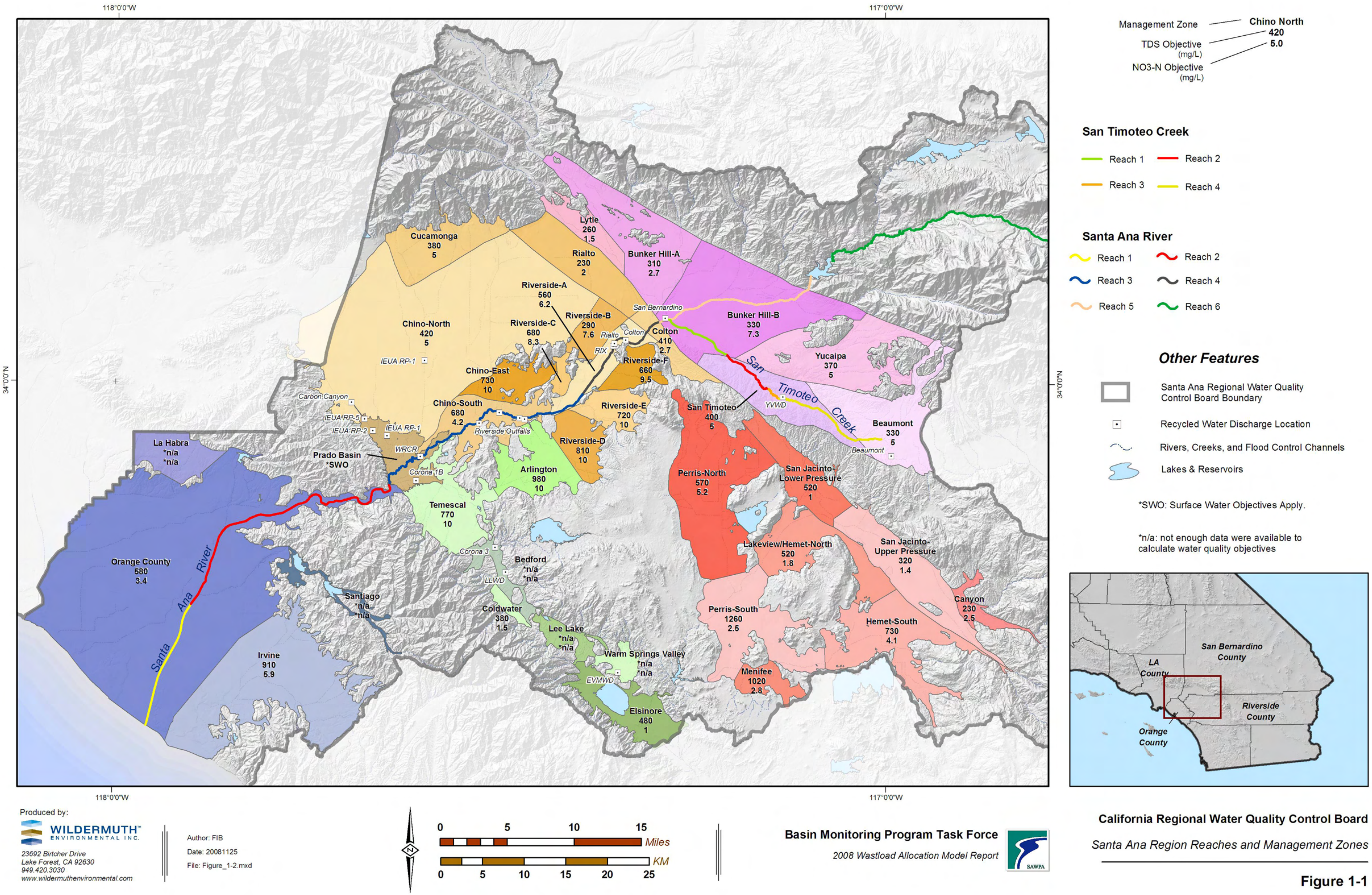
Section 1 Introduction describes the summary of previous work, the wasteload allocation approach, and the scope of work for this project.

Section 2 Model Description and Calibration describes the WLAM and its calibration.

Section 3 Comparison of Updated and Previous Models compares the updated model and the 2003 model. A description of the results and a discussion of the differences are provided herein.

Section 4 Planning Scenarios provides a description and evaluation of the planning scenarios evaluated with the WLAM.

Section 5 References provides the references that were utilized in this modeling effort.



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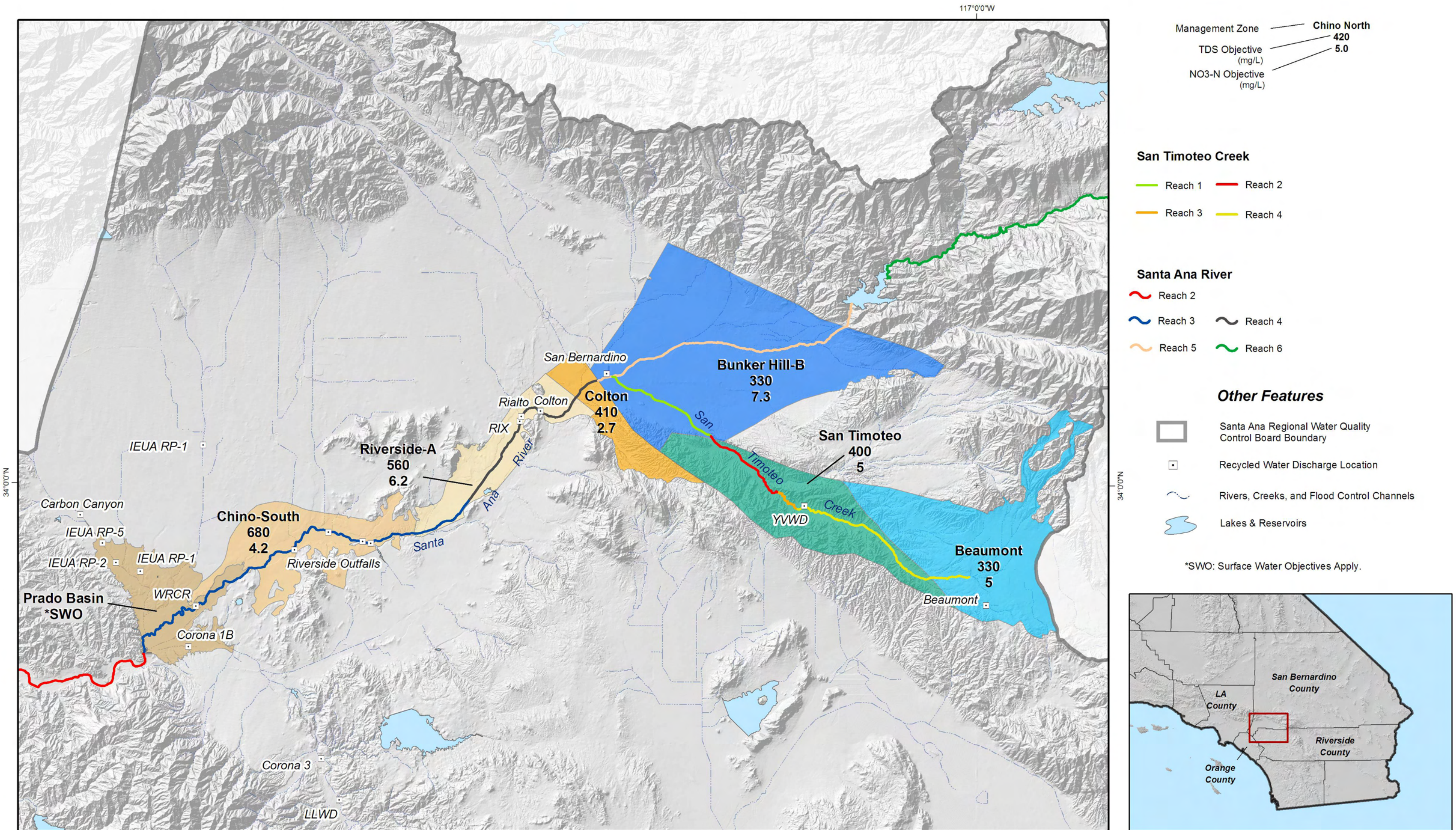
Basin Monitoring Program Task Force

2008 Wastload Allocation Model Report

California Regional Water Quality Control Board

Santa Ana Region Reaches and Management Zones

Figure 1-1



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Basin Monitoring Program Task Force

2008 Wasteload Allocation Model Report

SAWPA

California Regional Water Quality Control Board

Santa Ana Regional Water Quality Control Board Reaches and Management Zones Included in the WLA Model

Figure 1-2

2.1 Model Origin and Uses

The origin of the WLAM traces to the CBWCD and the Chino Basin Watermaster. These agencies wanted to estimate the storm water recharge in the Chino Basin that occurred in recharge basins, flood retention basins, and in unlined streams. WEI developed daily simulation models (RUNOFF and ROUTER) to estimate runoff, route the runoff through the Chino Basin drainage system, calculate recharge on a daily basis, and produce reports that summarized recharge performance. These models were initially developed for the western Chino Basin in 1994 (Mark J. Wildermuth, 1995) and were expanded to the entire Chino Basin in 1996 (WEI, 1998). Subsequently, the model was used in the Chino Basin to estimate the recharge performance of new basins and the recharge benefits of improved basin maintenance. The *Phase 2 Chino Basin Recharge Master Plan* (Black & Veatch, 2001) used the RUNOFF and ROUTER model results as a basis of recharge facility design and cost estimates.

In 2001, WEI updated the model to include water quality simulations and expanded the modeling area to the Santa Ana River Basin for the wasteload allocation investigation (WEI, 2002).

The WLAM was applied, along with the Storm Water Management Model (SWMM), to evaluate various water resources management alternatives and facilities for the Beaumont area (WEI, 2006).

WEI added a root zone (or top soil zone) soil moisture accounting module, ROOTZONE module, to the WLAM, and the WLAM became known as the R4 model (RAINFALL, RUNOFF, ROUTER, and ROOTZONE). The R4 model can be used to simulate rainfall infiltration to the soil zone, irrigation demand, evapotranspiration consumption, and deep percolation below root zone. WEI has successfully applied the R4 model to estimate 40 years of historical surface recharge in the Beaumont (report in preparation) and Arlington (WEI, 2008) Basins and 70 years of historical surface recharge in the Chino Basin (WEI, 2007).

2.2 Modeling Purpose and Goals

The modeling goals of this investigation are to estimate:

- Discharge, associated TDS and TIN concentrations in the Santa Ana River and its tributaries, and streambed recharge
- TDS and TIN metrics at key locations and in streambed recharge for selected reaches

These goals were accomplished by estimating long-term daily discharge time histories and associated TDS and TIN concentrations for the Santa Ana River and its major tributaries, assuming constant land use and POTW recycled water discharges for 2010 and 2020. Holding land use and POTW discharges constant for a fifty-year precipitation period (1950 through 1999) resulted in a stationary time series that includes wet and dry periods and, thus, allowing for the determination of statistics that could be used to evaluate the effectiveness of the current wasteload allocation included in the 2004 Basin Plan Amendment**.** This approach can also be used to test the effectiveness of new wasteload allocation proposals should the 2004 wasteload allocation be found not protective of the groundwater recharge beneficial use.

2.3 Wasteload Allocation Model

2.3.1 Model Organization

As illustrated in Figure 2-1, the model is organized into two major components or modules: RUNOFF and ROUTER. The RUNOFF module computes daily runoff from the land surface from daily precipitation, based on land use and soil data. The ROUTER module routes storm water runoff and all other point and nonpoint loads through the drainage system. The RUNOFF and ROUTER modules contain hydrologic, hydraulic, and water quality components. Detailed explanations of the algorithms used are provided in the sections that follow.

2.3.2 Rainfall Runoff Process

Daily runoff is estimated using a combination of methods:

- Runoff from the valley floor and some mountainous areas is calculated using a modified version of the method described in *Urban Hydrology for Small Watersheds* (USDA, 1986) and other references (SCS, 1985; Limbrunner, 2005).
- Daily discharge data from the USGS is used directly for mountainous areas where discharge records are complete.
- For small mountain watersheds with partial or no measured records, estimates of daily discharge are developed from nearby gaged watersheds, using regional analysis (regression or areal proration).

The mountain areas consist of the watersheds located in the San Bernardino, San Gabriel, and Santa Ana Mountains, and other mountainous/hill boundary areas. Mountain watershed hydrologic processes are similar to valley floor processes; though, some mountain watersheds produce sustained base flows and delayed runoff due to groundwater and snow pack storage. Measured daily discharges from mountain areas are assumed to be stationary; that is, their daily discharge statistics do not change over time due to influences from land development or other anthropogenic activities.

In contrast, valley floor areas are in a constant state of change, as land is converted from natural to agricultural and then to urban uses. There are no stationary historical stream discharge or water quality data in the valley floor area that can be used to estimate daily discharge and associated water quality statistics. Valley floor runoff is estimated using the Soil Conservation Service (SCS) method described in Section 4 of Chapter 10 of the *National Engineering Handbook* (NRCS, 2000).

The SCS method is based on the assumption that the ratio of actual retention to potential retention is same as the ratio to actual runoff to the effective rainfall. This is described mathematically as:

$$\frac{F}{S} = \frac{Q}{P - I_a} \tag{1}$$

Where F = the actual retention after runoff begins
S = the potential retention after runoff begins (S > F)
Q = the runoff
I_a = the initial abstraction
P = total rainfall

The continuity of storm water can be written as:

$$P = Q + F + I_a \tag{2}$$

This equation states that total rainfall is the sum of runoff, retention, and the initial abstraction. The equation can be rearranged as:

$$F = (P - I_a) - Q \tag{3}$$

Substituting equation (3) to (1) and rearranging for the total storm runoff (*Q*) results in the runoff equation:

$$Q = \frac{(P - I_a)^2}{(P - I_a) + S} \tag{4}$$

This is the basic rainfall-runoff relationship used in SCS method. Figure 2-2 illustrates the relationship between SCS method variables.

After reviewing results from many small experimental watersheds, Victor Mockus, the developer of the SCS method, developed an empirical relationship between the initial abstraction and the potential retention, which is expressed as:

$$I_a = 0.2S \tag{5}$$

By substituting I_a into equation (5), the rainfall-runoff equation becomes:

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S} \qquad when\, P > I_a \tag{6}$$

The potential retention (*S*) consists mainly of the infiltration that occurs after runoff begins and remains constant for an individual storm because it is the maximum retention that can occur under existing conditions if the storm continues without limit. A succession of storms increases soil moisture and reduces infiltration capacity, or potential retention (*S*). Conversely, periods of dry weather reduce soil moisture and increase *S*. With the SCS method, the change in *S* is based on an antecedent moisture condition (AMC), which is determined by the total rainfall in the 5-days preceding a storm. The *National Engineering Handbook* defines three levels of AMCs:

- AMC-I Lowest runoff potential. The Watershed soils are dry enough for satisfactory plowing or cultivation to take place.

- AMC-II The average condition.
- AMC-III The highest runoff potential. The watershed is practically saturated from antecedent rains.

The AMC-I condition is the lower limit of soil moisture, or the upper limit of potential retention *S*. Conversely, the AMC-III condition is the upper limit of soil moisture, or the lower limit of *S*.

The SCS simplified equations 4 and 6 through the introduction of the curve number (CN).

$$CN = \frac{1000}{10+S} \tag{7}$$

The practical implication of this equation is that the CN approaches 100 when *S* approaches zero (when retention is negligible), and the CN approaches zero when *S* approaches infinity. Therefore, the CN indicates the runoff potential—the higher the CN, the higher the potential. The *National Engineering Handbook* contains a table of CNs for hydrologic soil types and various land use types and conditions for the AMC-II condition. Many hydrology manuals contain similar tables, modified for local conditions. Table 2-1 lists SCS method CNs, which were reproduced from the *Riverside County Hydrology Manual* (County of Riverside, 1978).

2.3.2.1 Curve Number Variability

Rainfall-runoff data do not fit the CN runoff concept precisely due to the variability of rainfall intensity and duration, total rainfall, AMCs, cover density, stage of growth, and temperature. This variability is accounted for by adjusting the curve numbers.

The *National Engineering Handbook,* chapter 10 (NRCS, 2000), contains a table of empirically determined CNs for three AMCs: CN_1, CN_2, and CN_3. This table also provides values for AMC-I and AMC-III based on average AMC-II conditions. WEI developed the following equations such that CN_1 and CN_3 (for AMC-I and AMC-III) could be derived from CN_2 (AMC-II) automatically within the model:

$$CN_1 = \frac{CN_2}{2.27 - 0.0125 * CN_2} \tag{8a}$$

$$CN_3 = \frac{CN_2}{0.44 + 0.0055 * CN_2} \tag{8b}$$

Figure 2-3 shows the data for CN_1, CN_2, and CN_3, and the fitted curves. To estimate curve numbers for given soil conditions, values were interpolated between CN_1 and CN_3, using soil moisture retention capacity. This approach is based on the work completed by Limbrunner et al. (2005) and is listed below.:

$$CN(t) = (CN_3 - CN_1) * \frac{S(t)}{S_{\max}} + CN_1 \tag{9}$$

Where $S(t)$ is a variable that represents top soil zone storage at time t, and S_{max} is the maximum allowable storage under dry conditions. The storage variable is tracked on a daily basis such that $CN(t)$ can be tracked on a daily basis.

The value of the CN is a function of soil properties and land use data. Soil data is contained in soil surveys prepared by the SCS (1917, 1977, & 1980). The RUNOFF module computes daily runoff from each hydrologic area and writes these estimates to binary files that are subsequently used as input to the ROUTER module. The TDS and TIN concentrations associated with the daily runoff are generated from empirical relationships that relate TDS and TIN concentrations to the volume of runoff generated from each land use. The CN and the empirical relationships used to estimate the TDS and TIN concentrations of runoff are refined in calibration.

The RUNOFF module data requirements include:

- precipitation data
- daily evaporation data
- daily discharge data for mountain watersheds
- SCS soil surveys
- land use maps
- drainage maps
- as-built or design plans for all flood retention/recharge spreading basins and flood control facilities

2.3.3 Channel and Reservoir Routing

The ROUTER module is used to route the runoff estimated with the RUNOFF module through the drainage system in the upper Santa Ana watershed. The drainage system is descretized into nodes and links. The ROUTER module utilizes a routing plan that is based on a node-link pattern that describes the inflow or concentration points from the hydrologic areas of the RUNOFF module and the directional flow logic dictated by the streams, flood control channels, and retention basins. Runoff from hydrologic areas, non-tributary discharges, and boundary discharges are concentrated at nodes. Discharges are routed downstream from node to node via "links." The links are used to represent channels, flood control basins, conservation basins, and wetlands.

Routing through flood control basins, conservation basins, and wetlands is based on the continuity or mass balance equation (Viessman & Lewis, 1995). The continuity equation for flood analysis is expressed as:

$$\frac{\Delta S}{\Delta t} = I - O \qquad (10)$$

Where ΔS = the change of storage

Δt = the time step

I = inflow

O = outflow

This equation states that the storage change during a given period of time is the difference between total inflow and outflow over the same period. This equation was modified for the WLAM as follows:

$$\frac{\Delta S}{\Delta t} = I - O + P_r - E_v - P_c \qquad (11)$$

Where:

P_r = direct precipitation

E_v = evaporation

P_c = percolation

For retention and groundwater recharge purposes, the WLAM uses rating curves for water storage facilities. For specified elevations, the link data file contains surface area, storage volume, discharge rate (for up to two outflow facilities), and percolation rate information.

The WLAM runs on a daily time step, but reservoirs are simulated on a smaller time step (more than 240 times steps per day) to achieve numerical stability.

Discharges are translated in channels without storage effects and include losses to recharge (in unlined or partially lined stream channels) and evaporation (from water surfaces). The ROUTER module uses Manning's equation to calculate velocity and the representative hydraulic elements of a channel. Manning's equation is as follows (in English units):

$$Q = \frac{1.486}{n} * A * R^{2/3} s^{1/2} \qquad (12)$$

Where:

Q = the discharge in cubic feet per second (cfs)

A = the cross-sectional area (ft^2)

R = the hydraulic radius (ft)

s = the slope of the energy grade line and is approximated as the channel slope

n = Manning's roughness coefficient

Streambed recharge is equal to:

$$S_{rj} = L_j * W_j * P_{rj} \qquad (13)$$

Where:

S_{rj} = the streambed recharge in link *j* (ft^3/day)

L_j = the length of link *j* (ft)

W_j = the permeable wetted perimeter in link *j* (ft)

P_{rj} = the daily percolation rate in link *j* (ft/day)

For constructed channels and storm drains, the channel geometry is directly entered into the ROUTER input files, and the ROUTER module computes the hydraulic elements of the channel. The hydraulic elements consist of a lookup table that includes the relationships of the cross-section area, top width, hydraulic radius, weighted Manning's *n*, and conveyance to depth. Channel cross-section data can be highly irregular for natural channels or channels that are predominantly natural. The Santa Ana River and portions of San Timoteo Creek were considered natural channels in this investigation. For natural channels, hydraulic elements were based on a HEC-RAS model, developed by the United States Army Corps of Engineers (USACE) for the Santa Ana River, and on topographic maps that were obtained from the County of Riverside for San Timoteo Creek.

Daily, monthly, and annual discharge/recharge volumes are computed by the ROUTER module. The results of the ROUTER module are written to output files, which are imported into spreadsheets for analysis.

2.3.4 Water Quality Constituents

2.3.4.1 Total Dissolved Solids

TDS is treated as a conservative constituent, it is assumed to not interact with other water quality parameters. All inflows to a model node have an associated TDS concentration. Discharges and associated TDS concentrations are completely mixed at each node and a discharge-weighted composite TDS concentration is computed and routed through each link to the downstream node. TDS concentrations can increase in a link due to evaporation.

2.3.4.2 Total Inorganic Nitrogen

TIN is a non-conservative constituent. The loss of TIN is calculated as a first order, linear sink within each link. TIN loss in a link is computed as:

$$C_{TIN_{ds}} = C_{TIN\,us} * e^{-kt} \tag{14}$$

Where:

$C_{TIN_{ds}}$ = the TIN concentration discharged downstream from link *j* in mg/L-N

$C_{TIN\,us}$ = the TIN concentration discharged to link *j* from upstream links and local runoff and point loads in mg/L-N

k = the reaction rate (day^{-1})

t = the retention time, which is computed as reach length divided by the translation time through the link (day)

2.3.5 Computational Time Step and Simulation Period

The computational time step or period used in this study was one day. This period was selected due to modeling accuracy issues and data availability. Using longer periods, such as weeks, months, seasons, or a year, would lead to:

- Gross over-estimates of recharge in channels and conservation basins
- Underestimates of TDS and TIN concentrations in surface water discharge and streambed recharge during dry-weather discharge (the majority of the year)
- Overestimates of TDS and TIN concentrations in surface water discharge and streambed recharge during wet-weather discharge

Errors occur with long time steps because the estimated inflow and associated constituent mass is smeared out uniformly over the computational period. Runoff generally comes from storms that last a couple of days to less than one day.

Data availability also drives the selection of a time period. Daily discharge data is readily available from the USGS in digital format. As with discharge data, spatially representative, long-term, daily rainfall data are readily available in digital format. Higher frequency data (data with a time period of less than one day) are generally not available. The computational time step of one day was selected as a compromise between computational accuracy and data availability.

The simulation period used in this study spans October 1, 1950 through September 30, 1999, a period of 50 years or 18,263 days of continuous simulation.

2.4 Description of Model Data

The data types and sources used to build the WLAM files are discussed below. The majority of these data were collected from the San Bernardino County Flood Control District (SBCFCD), the USGS, the Riverside County Flood Control and Water Conservation District (RCFCWCD), and the County of Los Angeles. Specific data used include:

- Hydrologic subarea or storm water drainage area
- Precipitation data
- Land use data
- Hydrologic soil data
- Evaporation data
- Stream discharge data for mountain watersheds
- As-built or design plans and operational data for all flood retention and spreading basins and flood control facilities, including:
    - Channel geometry and type of lining (permeable, impermeable, or composite)
    - Rating tables for outlets of each flood retention and spreading basin
    - Relationships for the area and storage to water surface elevation for

each flood retention and spreading basin
  - Depth-percolation rate relationships for each flood retention and spreading basin
  - Rating tables for diversions
- Stream bottom percolation data
- Time histories of discharge and TDS and TIN concentrations for non-tributary discharges
- Reaction rate coefficients for nitrogen loss

Hydrologic Simulation Area. Figure 2-4 shows the hydrologic simulation areas (HSAs). The natural drainage areas were delineated from a USGS map and digital elevation model (DEM) data. The man-made storm water drainage system was overlain on the natural drainage system, and the drainage area was modified. In the last WLAM study, the total number of HSAs on the valley floor was 220, each with an average size of approximately 2,720 acres. For this study, the HSA coverage was further refined in the Prado, Arlington, Fontana, and Beaumont areas. For this study, the total number of HSAs is 259, each with an average size of approximately 2,320 acres.

Precipitation Data. Forty-three precipitation stations in the basin—with historical data covering the majority of the simulation period—were selected for use in the model. These data were obtained from Los Angeles, San Bernardino, and Riverside Counties. The stations are listed in Table 2-2, and their locations are shown in Figure 2-5.

Land Use Data. Existing and future land use data within the watershed was developed based on available Southern California Association of Governments (SCAG) information for 2000. SCAG compiled land use data for 1990, 1993, 2000, and 2005. The 2001 data fits the middle of calibration period and was used for calibration. SCAG classifies land use based on the Anderson land use code system, which numerically distinguishes various land use types.

The WLAM uses a different land use system that categorizes land use based on water use, runoff, and TIN/TDS wash-off rates. Table 2-3 lists the land use types used in the previous wasteload allocation study. As shown in this table, the previous study included 21 land use types. For this study, the total number of land use types was reduced to 12, as shown in Table 2-4. This table also shows the average percentage of impervious area for each land use type. These percentages were estimated based on published data in the county hydrology manuals (Riverside County, 1979; San Bernardino County, 1986). Pervious areas consist of agricultural uses, urban landscaping, fields, and undeveloped areas that allow some precipitation to infiltrate into the ground. Impervious areas consist of roofs, streets, parking lots, and other areas that do not allow for the percolation of precipitation or runoff.

Table 2-5 provides the relationship between Anderson and WLAM land use codes, and Table 2-6 summarizes land uses in the WLAM land use code system by area. Land use data was used to estimate the amount of pervious and impervious areas within each hydrologic simulation area. Figure 2-6 shows the distribution of land uses in the upper watershed, based on the SCAG data that was converted to the WLAM land use system. Figure 2-7 shows the drainage areas that land use statistics were calculated for in Table 2-6.

Soils and Hydrologic Soil Type Data. Hydrologic soil type delineations for the watershed are based on SCS soil surveys of the study area—*Soil Survey of San Bernardino County, Southwestern Part* (SCS, 1977), *Soil Survey of Western Riverside County* (SCS, 1971) *Soil Survey of the Pasadena Area, California* (SCS, 1917)—and the *San Bernardino County Flood Control Manual* (San Bernardino County, 1986). In the SCS method, soils are classified as type A, B, C, or D. Table 2-7 describes each land use type by SCS soil type.

Figure 2-8 shows the areal distribution of hydrologic soil types, based on mapping by San Bernardino County, Riverside County, and the SCS. In San Bernardino County, soil types A and B occupy 92 percent of the area. Whereas, in Riverside County, soil types A and B occupy only 43 percent of the area. This disparity may be due to differences in the geologic formations of the two areas, but it may also be due to different surveyors. Los Angeles County accounts for about 2 percent of the model area.

Hydrologic soil types and land uses were used to develop CNs. A CN reflects a soils ability to retain rainfall from storm events. CNs are lower for well-draining sandy soils and higher for poor-draining silty clay soils. CNs were estimated for the pervious part of each land use type within each drainage area, based on the various soil types and land uses recommended in the published county hydrology manuals (Riverside County, 1979; San Bernardino County, 1986). The values range from a low of 37 to a high of 89. Impervious areas were assumed to have a CN of 98. Table 2-7 lists the initial CN estimates. Please note that some CNs were modified during calibration.

Evaporation Rate. Evaporative losses of water stored in flood control and spreading basins were based on evaporation data that was collected at the Puddingstone Reservoir, located west of the City of Pomona. The County of Los Angeles collects data at this station daily.

Percolation Rates for Conservation Basins and Channels. Depth-percolation rate relationships for flood retention and conservation basins in the Chino Basin were based on estimates that were developed from CBWCD recharge monitoring programs and from the Chino Basin Watermaster Phase 2 Recharge Master Plan. Percolation rates for all other conservation basins and permeable channels were initially estimated (Moreland, 1972) and refined in calibration.

Daily Discharge Data. Daily discharge data were obtained from the USGS. Table 2-8 lists the stations used in this study, and Figure 2-9 shows the locations of these stations

Operational Characteristics of Flood Control and Conservation Basins. The operations of the flood control and spreading basins were based on static rule curves that define the operational relationship of storage, surface area, and outflow as a function of water surface elevation in each basin. Operational data for each basin were acquired from existing engineering documents, as-built construction drawings, and communications with USACE, SBCFCD, Pomona Valley Protective Association, and CBWCD staff.

TDS and TIN Data. TDS and TIN data were used to develop TDS and TIN generation curves for runoff, to identify the TDS and TIN concentrations in non-tributary inflows, and as calibration targets. These data were obtained from the Chino Basin Watermaster, the OCWD, the POTWs, the RCFCWCD, the Regional Board, the SBCFCD, and the USGS. Generally, each sampling event reported by these entities includes ammonia, nitrite, and nitrate, or nitrate and ammonia. TIN was assumed to be the sum of the reported inorganic nitrogen compounds: either ammonia + nitrite + nitrate, or ammonia + nitrate, respectively. Overall, nitrite concentrations are very small, and their absence does not materially affect the estimation of TIN concentrations. TIN estimates were not made if either ammonia or nitrate were missing. The number of TDS and TIN observations at selected stations during the calibration period are listed below:

Station	Number of Observations	
	TDS	TIN
Santa Ana River at MWD Crossing	849	163
Santa Ana River at below Prado Dam	4,315	264

TDS and TIN Generation Curves. The TDS and TIN concentrations in rainfall runoff from valley floor areas were estimated from data that were collected by the Chino Basin Watermaster and the Counties of San Bernardino and Riverside and from conservation basin TDS and TIN measurements made by the Chino Basin Watermaster. These concentrations were compared to measured or RUNOFF module-estimated discharges, and simple relationships between TDS, TIN, and runoff were developed for urban and mountain watersheds. These relationships were established for the last wasteload allocation investigation (WEI, 2003). Since the last investigation, WEI has collected more runoff water quality data from the counties, but these data did not include discharge measurements. Without discharge data, the TDS and TIN generation curves could not be updated from the 2003 investigation.

Non-tributary discharges. Non-tributary discharges include discharges to surface water from POTWs, water transfers from groundwater basins, and state project water discharged at the OC-59 turnout in San Antonio Creek. Discharge, TDS, and TIN time history data for the calibration period were obtained from POTWs and the annual reports of the Santa Ana Watermaster and others.

Lake Elsinore Discharge. Discharge and associated TDS concentrations from Lake Elsinore for the calibration period were estimated from the annual reports of the Santa Ana River Watermaster for water years 1994/95 through 2005/06 (Santa Ana River Watermaster, 2006). The TIN in Lake Elsinore discharge for the calibration period was estimated from published Lake monitoring data (Black & Veatch, 1994).

Rising Groundwater. The WLAM is not dynamically linked to a groundwater model. Therefore, a time series of rising water discharge to the stream network was synthesized from discharge measurement data where rising water is assumed to be occurring. Specifically, rising groundwater was estimated for the Santa Ana River at Riverside Narrows and at Prado Dam. Rising water may occur at other locations in the stream system; however, due to the lack of data needed to define the spatial and temporal distribution of rising groundwater at other locations, such time series could not be synthesized for this study.

OCWD Wetlands. The OCWD constructed about 400 acres of wetlands in the Prado reservoir, which it uses to treat some of the discharge of the Santa Ana River and all of the effluent from the Western Riverside Regional Water Recycling Plant. Fifty percent of Santa Ana River discharge, up to 100 cfs, is diverted into the wetlands. The TIN in effluent that is discharged from the wetlands back to the Santa Ana River was assumed to be 1 mg/L-N. A slight TDS increase occurs in the effluent of the wetlands due to evaporation and transpiration.

2.5 Calibration

Calibration is a process in which parameter adjustments are made to match the dynamic behavior of the WLAM with the observed behavior of the streams being simulated. In the process of calibration, model parameters are adjusted, subject to reasonable bounds, with manual methods and automatic parameter estimation (inverse) methods to match observed discharge and water quality. The WLAM was calibrated first for surface water and subsequently for TDS and TIN. The calibration period was 1994 through 2006. The PEST code (Doherty, 2004) was used to assist in the calibration of the WLAM. During the calibration process, parameters are adjusted until the model-generated results fit a set of observations as closely as possible. PEST adjusts model parameters until the fit between model output and field observations are optimized in terms of the weighted least square residuals. PEST is a public domain code that applies the Gauss-Marquardt-Levenberg algorithm. PEST has been successfully applied in many fields of the geophysical sciences, including groundwater and surface water modeling (Doherty & Johnston, 2003; Zarriello & Bent, 2004). The calibration results discussed herein are the combined results of manual and automated calibration.

2.5.1 Calibration Targets

Surface water discharge and associated TDS and TIN concentrations were calibrated by comparing model-estimated values against observed values at key locations in the upper watershed. The calibration of the WLAM for surface water discharge has improved since the previous application of the WLAM (WEI, 2002).

2.5.2 Surface Water Discharge Calibration

The surface water discharge calibration effort started at the upstream end of San Timoteo Creek and proceeded downstream. Daily and monthly discharge estimates from the WLAM were compared to measured data. Figures 2-10 through 2-16 compare model results with measured daily discharges at San Timoteo Creek near Loma Linda, Santa Ana River at E Street, Santa Ana River at MWD Crossing, Temescal Creek above Main Street, Chino Creek at Schaefer Avenue, Cucamonga Creek near Mira Loma, and Santa Ana River inflow to the Prado Basin. Figure 2-17a (all discharges) and Figure 2-17b (low discharges) are scatter plots of monthly measured and modeled discharge at all calibration locations. These figures also list the correlation coefficient (R-square) of the two data series (0.92).

Table 2-9 summarizes the calibration statistics used to evaluate accuracy of the model. This table lists, by station, the R-square, the root mean square error, and the Nash-Sutcliffe Efficiency (NSE) coefficient. These statistics were calculated with a daily aggregated monthly discharge.

The R-square statistic describes the fraction of variance in the observed data that can be explained by the WLAM. For monthly total discharge, the R-square ranges from a low of 0.77 for Temescal Creek at Main Street to a high of 0.93 for Cucamonga Creek near Mira Loma, Santa Ana River at E Street, and Santa Ana River at MWD Crossing. The average for all stations is about 0.87. This means that for Cucamonga Creek near Mira Loma, 93 percent of the variation in the observed discharges can be explained by the WLAM using the parameters developed in calibration. The other 7 percent can be explained by variability in the observed precipitation and surface water discharge measurements and model conceptualization. An R-square of 1.0 indicates that the regression line perfectly fits the data. Monthly R-square statistics are used because of the timing of storms and the routing assumptions used in the WLAM. For example, if a storm occurs late in the day, the computed runoff will occur that day. The observed runoff could occur the following day. This causes significant differences between daily observed and daily estimated WLAM discharges. However, these differences are almost entirely removed at a monthly period of evaluation.

The Root Mean Square Error (RMSE) is a measure of how close a fitted line (model result) is to data points (observed values). For every model result, the distance between the modeled and measured value (the error) is squared. These values are then summed for all points and divided by the total number of points, after which the square root is taken. The squaring is done so negative values do not cancel positive values. For the WLAM, the RMSE ranges from a low of 22.1 acre-ft/month (or about 12 percent of the average monthly flow) at San Timoteo Creek near Loma Linda to a high of 155 acre-ft/month (or about 1 percent of the average monthly flow) for the Santa Ana River below Prado Dam.

The NSE is a widely used metric for measuring the predictive power of hydrologic models. The NSE is defined as one minus the sum of the absolute squared differences between the model-estimated values and the measured data points normalized by the variance of the measured values during the modeled period (Nash & Sutcliffe, 1970). As values are squared, this metric puts emphasis on the modeling accuracy of larger events. The NSE can range from $-\infty$ to 1. An efficiency of 1 corresponds to a perfect match of modeled discharge to measured discharge. An efficiency of 0 (E=0) indicates that the model predictions are as accurate as the mean of the measured data; whereas, an efficiency less than zero ($-\infty<E<0$) occurs when the measured mean is a better predictor than the model. The closer the NSE is to 1, the more accurate the model is. For the WLAM, the NSE ranges from a low of 0.71 for Temescal Creek at Main Street to a high of 0.92 for Santa Ana River at E Street and for Santa Ana River below Prado Dam.

2.5.2.1 Stream Bottom Percolation Rate

Stream bottom percolation rates were calibrated with field measurements and validated against data from other models. In March 2005, Seven Oaks Dam released water that was recorded at USGS gaging stations near Mentone and E Street in San Bernardino (as shown in Figure 2-9). During the March 1, 2005 to April 2, 2005 period, the recorded rainfall at the Loma Linda gage was about 0.08 inches on March 18 and about 0.73 inches on March 22; there was very little precipitation at the Mentone gages: 0.14 and 0.55 inches of precipitation were recorded on March 4 and March 22, respectively. This reservoir release and the minimal precipitation provided an opportunity to calculate channel losses (and percolation rates) in the Santa Ana River between Seven Oaks Dam and E Street. The percolation rate was adjusted for this reach of the Santa Ana River until the modeled percolation rate fit the measured field data. Figure 2-18 shows the time series of discharge at Mentone and the observed and model estimated discharges at E Street. The model estimated daily discharges that follow the measured data very closely. Figure 2-19 is a scatter plot of the model-calculated discharge versus the observed discharge at E Street. The R-square of the measured and modeled calculated discharges is 0.91. The stream bottom percolation rate was estimated to be 1.95 ft/day.

The Chino Basin Watermaster developed a groundwater model using USGS MODFLOW model code (WEI, 2007). This model was also used to estimate streambed percolation in the Santa Ana River within Reach 3. At the conclusion of the WLAM calibration, the WLAM results for Reach 3 of the Santa Ana River were compared to percolation estimates made with the Watermaster MODFLOW model. This comparison is illustrated in Figure 2-20. The annual percolation values are very similar: the maximum difference between the two model estimates is 19 percent in 2006, and the average difference over the calibration period is 6 percent. Figure 2-21 is a scatter plot of the two data sets; the R-square is about 0.75.

2.5.3 TDS and TIN Calibration

TDS and TIN calibration was initiated at the conclusion of the hydraulic model calibration. The calibration period for TDS and TIN is the same as the hydraulic model (1994 through 2006). Due to the paucity of data, the use of objective numerical calibration criteria was not applicable. Calibration was completed manually for Santa Ana River at the MWD Crossing and Santa Ana River below Prado Dam. About 15 simulations were done to calibrate TDS, and 15 simulations were done to calibrate TIN. Figures 2-22 and 2-23 compare observed TDS and TIN concentrations and WLAM estimates at Santa Ana River at the MWD Crossing, respectively. Figures 2-24 and 2-25 compare observed TDS and TIN concentrations and WLAM estimates for Santa Ana River below Prado Dam, respectively.

The reaction rate coefficients developed in calibration to estimate nitrogen loss in surface discharge were 0.1 upstream of Riverside Narrows and 0.25 downstream of Riverside Narrows. The TDS and TIN concentrations in the rising water components near Riverside Narrows and Prado were:

Rising Water Area	TDS (Mg/L)	TIN (mg/L-N)
Riverside Narrows	900	11
Prado Vicinity	1,100	11

These are the same values derived in the previous wasteload allocation study (WEI, 2002) and are based on historical groundwater and surface water quality measurements and WLAM calibration.

2.6 Limitations in the Use of the WLAM

The WLAM, as currently developed and calibrated, can be used to estimate the TDS and TIN concentrations in surface water discharge and streambed recharge for the land use and groundwater conditions for which it has been calibrated. Assuming these conditions, the WLAM can be used to estimate surface water discharges and the TDS and TIN impacts of changes in recycled water and other non-tributary discharges to the Santa Ana River drainage system and, in particular, to Chino Basin tributaries, San Timoteo Creek, and the Santa Ana River between E Street and Prado Dam.

Table 2-1

SCS Method Curve Numbers[1,2]

Cover Type [3]	Quality of Cover [4]	Soil Group			
		A	B	C	D
Natural Covers					
Barren (Rockland, eroded and graded land)		78	86	91	93
Chaparral, Broadleaf (Manzanita, ceanothus and scrub oak)	Poor	53	70	80	85
	Fair	40	63	75	81
	Good	31	57	71	78
Chaparral, Narrowleaf (Chamise and redshank)	Poor	71	82	88	91
	Fair	55	72	81	86
Grass, Annual or Perennial	Poor	67	78	86	89
	Fair	50	69	79	84
	Good	38	61	74	80
Meadows or Cienegas (Areas with seasonally high water table, principal vegetation is sod forming grass)	Poor	63	77	85	88
	Fair	51	70	80	84
	Good	30	58	72	78
Open Brush (Soft wood shrubs - buckwheat, sage, etc.)	Poor	62	76	84	88
	Fair	46	66	77	83
	Good	41	63	75	81
Woodland (Coniferous or broadleaf trees predominate. Canopy is at least 50 percent)	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	28	55	70	77
Woodland, Grass (Coniferous or broadleaf trees with a canopy density from 20 to 50 percent)	Poor	57	73	82	86
	Fair	44	65	77	82
	Good	33	58	72	79
Urban Covers					
Residential or Commercial Landscaping (Lawn, shrubs, etc.)	Good	32	56	69	75
Turf (Irrigated and mowed grass)	Poor	58	74	83	87
	Fair	44	65	77	82
	Good	33	58	72	79
Agricultural Covers					
Fallow (Land plowed but not tilled or seeded		76	85	90	92
Legumes, Close Seeded (Alfalfa, sweetclover, timothy, etc.)	Poor	66	77	85	89
	Good	58	72	81	85
Orchards, Evergreen (Citrus, avocados, etc.)	Poor	57	73	82	86
	Fair	44	65	77	82
	Good	33	58	72	79
Pasture, Dry land (Annual grasses)	Poor	67	78		89
	Fair	50	69	79	84
	Good	38	61	74	80
Pasture, Irrigated (Legumes and perennial grasses)	Poor	58	74	83	87
	Fair	44	65	77	82
	Good	33	58	72	79
Row Crops (Field crops - tomatoes, sugar beets, etc.)	Poor	72	81	88	91
	Good	67	78	85	89
Small grain (Wheat, oats, barley, etc.)	Poor	65	76	84	88
	Good	63	75	83	87

Notes:

1. All curve numbers (CN) are for Antecedent Moisture Condition (AMC) II.
2. Reproduced from Hydrology Manual, Riverside County Flood Control and Water Conservation District, 1978
3. Quality of cover definitions:

    Poor - Heavily grazed or regularly burned areas. Less than 50 percent of the ground surface is protected by plant cover or brush and tree canopy.

    Fair - Moderate cover with 50 percent to 75 percent of the ground surface protected.

    Good - Heavy or dense cover with more than 75 percent of the ground surface protected.

4. See Plate C-2 in Hydrology Manual, Riverside County Flood Control and Water Conservation District for a detailed description of cover types

Table 2-2
Rainfall Stations Used in the WLAM

Thiessen Polygon ID	Station Number	Station Name	County	Elevation (ft)	Recording Period			Station Used for Missing Data
					Start	End	Average (in/yr)	
1	1021AUTO	Mira Loma Space Center	SB	804	1943	2006	12.0	
2	1026	Ontario Fire Station	SB	986	1934	2006	15.9	
3	2071	San Bernardino City - Devil	SB	1,870	1928	2006	23.7	
4	2159AUTO	Lytle Creek At Foothill Boulevard	SB	1,225	1948	2006	13.8	
5	2166	San Bernardino City - Newmark	SB	1,415	1928	2006	19.3	
6	2198	San Bernardino City - Lytle Creek	SB	1,225	1927	2006	16.2	
7	3014AUTO	Oak Glen	SB	4,680	1946	2006	27.1	3015
8	3273	Loma Linda (V.G.C.)	SB	1,063	1893	2006	13.4	3337 & 3000
9	1079	Chino - Imbach	SB	642	1929	2006	12.4	1026
10	1085	San Antonio Heights C.D.F.	SB	1,901	1944	2006	21.6	1290
11	3129	Yucaipa C.D.F.	SB	2,660	1951	2006	16.1	3014AUTO
12	1034	Claremont Pomona College	LA	1,196	1896	2006	16.8	1137
13	1067	Chino Substation - Edison	SB	670	1927	2006	13.8	1262
14	1175	Alta Loma Forney	SB	1,865	1956	2006	19.8	1192
15	2005B	Declez	SB	1,115	1943	2006	12.6	2005BAUTO
16	2009A	Reche Canyon - Manton	SB	2,030	1919	2006	13.3	3059AUTO
17	2015AUTO	Del Rosa Ranger Station	SB	1,747	1943	2006	18.7	2359
18	2017AUTO	Fontana 5N (Getchell)	SB	1,959	1958	2006	24.3	2017
19	2037AUTO	Lytle Creek Ranger Station	SB	2,730	1958	2006	27.1	2037
20	2146AUTO	San Bernardino County Hospital	SB	1,126	1985	2006	16.9	2146
21	2194	Fontana Union Water Company -	SB	1,289	1926	2006	16.7	2206 & 2206AUTO
22	2286AUTO	San Bernardino City - Hanford	SB	1,030	1930	2006	13.5	2286
23	3162AUTO	Santa Ana P.H. #3	SB	1,980	1980	2006	16.1	3162
24	1019AAUTO	Upland - Chapel	SB	1,601	1960	2006	18.5	1019
25	3058	Mentone - Blue Goose	SB	1,650	1928	2006	14.3	3120 & 3337AUTO
26	13	Beaumont	R	2,613	1929	2006	17.2	
27	35	Chase & Taylor	R	1,055	1930	2006	16.8	
28	67	Elsinore	R	1,285	1887	2006	11.9	
29	75	Temescal Cyn Ws	R	1,220	1905	2006	17.5	
30	177	Riverside East	R	986	1925	2006	10.4	
31	178	Riverside North	R	800	1925	2006	10.4	
32	179	Riverside South	R	840	1881	2006	10.1	
33	246	Wildomar	R	1,255	1907	2006	13.9	
34	7	Arlington	R	805	1963	2006	9.9	179
35	31	Calimesa	R	2,400	1958	2006	16.8	3014AUTO
36	36	Cherry Valley	R	2,860	1956	2006	19.3	13
37	44	Corona North	R	638	1956	2006	19.3	35
38	100	La Sierra	R	712	1905	2006	17.5	179
39	102	Lake Mathews	R	1,400	1905	2006	17.5	
40	202	Santiago Peak	R	5,638	1950	2006	33.5	102
41	250	Woodcrest	R	1,557	1956	2006	9.5	102
42	71	Gavilan Springs	R		1978	2006	12.6	102
43	265	Indian Hills	R	840	1956	2006	9.5	178

Table 2-3
Land Use Types Used in the 2003 Wasteload Allocation Study

WEI Land Use Code	Land Use Category/Description	Percentage of Impervious Area
1	Residential Rural Low Density	40
2	Residential Low Density	60
3	Residential High Density	80
4	Commercial	90
5	Industrial A	100
6	Industrial B	90
7	Industrial C	60
8	Industrial D	10
9	Industrial E	0
10	School	60
11	Agricultural, Non-Irrigated Crops & Pasture	2
12	Agricultural, Irrigated Crops & Pasture	2
13	Agricultural, Orchard & Vineyard	2
14	Agricultural, Other (Truck)	2
15	Agricultural, Nurseries (Truck)	2
16	Dairies and Livestock	5
17	Horse Ranch	2
18	Poultry Operations	90
19	Golf Courses, Cemeteries, Rec Parks, Gardens	5
20	Water Facilities	90
21	Vacant	0

Notes:

Reproduced from Hydrology Manual, Riverside County Flood Control and Water Conservation District, 1978, Plate D-5-6

Reproduced from Hydrology Manual, San Bernardino County , 1986, Figure C-4

Table 2-4
Land Use Types Used in the 2008 Study

WEI Land Use Code	Land Use Category/Description	Percentage of Impervious Area
1	Low Density Residential	30
2	Medium Density Residential	50
3	High Density Residential	75
4	Commercial	90
5	Industrial	90
6	Orchards and Vineyards	2
7	Irrigated Cropland and Improved Pasture Land, Golf course	2
8	Parks, schools	80
9	Dairy, poultry, horse ranch, etc	0
10	Impervious	100
11	Undeveloped	2
12	Native/mountain	2

Notes:

Reproduced from Hydrology Manual, Riverside County Flood Control and Water Conservation District, 1978, Plate D-5-6

Reproduced from Hydrology Manual, San Bernardino County , 1986, Figure C-4

Table 2-5
Land Use Conversion Table from Anderson Code to WLA Model Land Use Types

Anderson Land Use Classification	Description	Wildermuth Environmental Land Use Types
1000	URBAN OR BUILT-UP	
1100	Residential	
1110	Single Family Residential	Industrial C
1111	High Density Single Family Residential	Industrial C
1112	Low Density Single Family Residential	School
1120	Multi-Family Residential	Industrial C
1121	Mixed Multi-Family Residential	Industrial C
1122	Duplexes and Triplexes	Industrial C
1123	Low-Rise Apartments, Condos, Townhouses	Industrial C
1124	Medium-Rise Apartments and Condos	Industrial C
1125	High-Rise Apartments and Condos	Industrial C
1130	Mobile Homes and Trailer Parks	Industrial C
1131	Trailer Parks and Mobile Home Courts, High Density	Industrial C
1132	Trailer Parks and Mobile Home Courts, Low Density	Industrial C
1140	Mixed Residential	Industrial C
1150	Rural Residential	School
1151	Rural Residential High Density	School
1152	Rural Residential Low Density	School
1200	Commercial and Services	Agricultural, Non-Irrigated Crops & Pasture
1210	General Office Use	Agricultural, Non-Irrigated Crops & Pasture
1211	Low - Medium Rise Major Office Use	Agricultural, Non-Irrigated Crops & Pasture
1212	High Rise Major Office Use	Agricultural, Non-Irrigated Crops & Pasture
1213	Skyscrapers	Agricultural, Non-Irrigated Crops & Pasture
1220	Retail Stores and Commercial Services	Agricultural, Non-Irrigated Crops & Pasture
1221	Regional Shopping Mall	Agricultural, Non-Irrigated Crops & Pasture
1222	Retail Centers	Agricultural, Non-Irrigated Crops & Pasture
1223	Modern Strip Development	Agricultural, Non-Irrigated Crops & Pasture
1224	Older Strip Development	Agricultural, Non-Irrigated Crops & Pasture
1230	Other Commercial	Agricultural, Non-Irrigated Crops & Pasture
1231	Commercial Storage	Agricultural, Non-Irrigated Crops & Pasture
1232	Commercial Recreation	Agricultural, Non-Irrigated Crops & Pasture
1233	Hotels and Motels	Agricultural, Non-Irrigated Crops & Pasture
1244	Attended Pay Public Parking Facilities	Agricultural, Non-Irrigated Crops & Pasture
1240	Public Facilities	Agricultural, Non-Irrigated Crops & Pasture
1241	Government Offices	Agricultural, Non-Irrigated Crops & Pasture
1242	Police and Sheriff Stations	Agricultural, Non-Irrigated Crops & Pasture
1243	Fire Stations	Agricultural, Non-Irrigated Crops & Pasture
1244	Major Medical Health Care Facilities	Agricultural, Non-Irrigated Crops & Pasture
1245	Religious Facilities	Agricultural, Non-Irrigated Crops & Pasture
1246	Other Public Facilities	Agricultural, Non-Irrigated Crops & Pasture
1247	Non-Attended Public Parking Facilities	Agricultural, Non-Irrigated Crops & Pasture
1250	Special Use Facilities	Agricultural, Non-Irrigated Crops & Pasture
1251	Correctional Facilities	Agricultural, Non-Irrigated Crops & Pasture
1252	Special Care Facilities	Agricultural, Non-Irrigated Crops & Pasture
1253	Other Special Use Facilities	Agricultural, Non-Irrigated Crops & Pasture
1260	Educational Institutions	Agricultural, Non-Irrigated Crops & Pasture
1261	Pre-Schools/Day Care Centers	School
1262	Elementary Schools	School
1263	Junior or Intermediate High Schools	School
1264	Senior High Schools	School
1265	Colleges and Universities	School
1266	Trade Schools	School
1270	Military Installations	School
1271	Base (Built-up Area)	School
1272	Vacant Area	Industrial E

Table 2-5
Land Use Conversion Table from Anderson Code to WLA Model Land Use Types

Anderson Land Use Classification	Description	Wildermuth Environmental Land Use Types
1273	Air Field	Industrial D
1300	Industrial	Agricultural, Irrigated Crops & Pasture
1310	Light Industrial	Agricultural, Irrigated Crops & Pasture
1311	Manufacturing and Assembly	Agricultural, Irrigated Crops & Pasture
1312	Motion Picture	Agricultural, Non-Irrigated Crops & Pasture
1313	Packing Houses and Grain Elevators	Agricultural, Irrigated Crops & Pasture
1314	Research and Development	Agricultural, Irrigated Crops & Pasture
1320	Heavy Industrial	Agricultural, Irrigated Crops & Pasture
1321	Manufacturing	Agricultural, Irrigated Crops & Pasture
1322	Petroleum Refining and Processing	Agricultural, Irrigated Crops & Pasture
1323	Open Storage	Agricultural, Irrigated Crops & Pasture
1324	Major Metal Processing	Agricultural, Irrigated Crops & Pasture
1325	Chemical Processing	Agricultural, Irrigated Crops & Pasture
1330	Extraction	Industrial E
1331	Mineral Extraction-Other than gas and oil	Industrial E
1332	Mineral Extraction-Oil and gas	Industrial E
1400	Transportation, Communications, and Utilities	Industrial D
1410	Transportation	Industrial D
1411	Airports	Industrial D
1412	Railroads	Industrial E
1413	Freeways	Industrial D
1414	Park and Ride Lots	Industrial D
1415	Bus Terminals and Yards	Industrial D
1416	Truck Terminals	Industrial D
1417	Harbor Facilities	NA
1418	Navigation Aids	NA
1420	Communication Facilities	
1430	Utility Facilities	Industrial D
1431	Electrical Power Facilities	Industrial E
1432	Solid Waste Disposal Facilities	Industrial D
1433	Liquid Waste Disposal Facilities	Industrial D
1434	Water Storage Facilities	Industrial D
1435	Natural Gas and Petroleum Facilities	Industrial D
1436	Water Transfer Facilities	Industrial E
1437	Improved Flood Waterways and Structures	Industrial E
1438	Mixed Wind Energy Generation and Percolation Basin	Industrial D
1440	Maintenance Yards	Industrial D
1450	Mixed Transportation	Industrial D
1460	Mixed Transportation and Utility	Industrial D
1500	Mixed Commercial and Industrial	Agricultural, Non-Irrigated Crops & Pasture
1600	Mixed Urban	Industrial C
1700	Under Construction	Agricultural, Orchard & Vineyard
1800	Open Space and Recreation	Industrial E
1810	Golf Courses	Residential Low Density
1820	Local Parks and Recreation	Residential Low Density
1830	Regional Parks and Recreation	Residential Low Density
1840	Cemeteries	Residential Low Density
1850	Wildlife Preserves and Sanctuaries	Industrial E
1860	Specimen Gardens and Arboreta	Residential Low Density
1870	Beach Parks	NA
1880	Other Open Space and Recreation	Agricultural, Orchard & Vineyard
1900	Urban Vacant	Agricultural, Orchard & Vineyard
2000	AGRICULTURE	Residential Low Density
2100	Cropland and Improved Pasture Land	Residential Low Density
2110	Irrigated Cropland and Improved Pasture Land	Residential Low Density
2120	Non-Irrigated Cropland and Improved Pasture Land	Residential Rural Low Density
2200	Orchards and Vineyards	Commercial

Table 2-5
Land Use Conversion Table from Anderson Code to WLA Model Land Use Types

Anderson Land Use Classification	Description	Wildermuth Environmental Land Use Types
2300	Nurseries	Residential High Density
2400	Dairy and Intensive Livestock	Industrial B
2500	Poultry Operations	Industrial A
2600	Other Agriculture	Residential Low Density
2700	Horse Ranches	Residential Low Density
3000	VACANT	Agricultural, Orchard & Vineyard
3100	Vacant Undifferentiated	Industrial E
3200	Abandoned Orchards and Vineyards	Industrial E
3300	Vacant With Limited Improvements	Industrial E
4000	WATER	Industrial D
4100	Water, Undifferentiated	Industrial D
4200	Harbor Water Facilities	NA
4300	Marina Water Facilities	NA
4400	Water Within a Military Installation	NA
4500	Area of Inundation	Industrial D

Table 2-6

Summary of Land Use by Drainage Area in the Valley Floor of the Modeling Domain[1]

WEI Land Use Code	Land Use Type	Drainage Area Upstream of E Street Gaging Station		Drainage Area Between E Street and Riverside Narrows		Chino Drainage Area		Temescal/ Prado Drainage Area	
		Area (mi^2)	Percentage	Area (mi^2)	Percentage	Area (mi^2)	Percentage	Area (mi^2)	Percentage
1	Low Density Residential	17	6%	21	12%	15	6%	26	10%
2	Medium Density Residential	40	15%	36	21%	62	24%	18	7%
3	High Density Residential	7	2%	5	3%	9	3%	2	1%
4	Commercial	11	4%	10	6%	25	10%	6	2%
5	Industrial	3	1%	4	3%	12	5%	3	1%
6	Orchards and Vineyards	9	3%	6	4%	3	1%	14	5%
7	Irrigated Cropland and Improved Pasture Land, Golf course	3	1%	3	2%	19	7%	4	1%
8	Parks, schools	7	3%	6	3%	8	3%	3	1%
9	Dairy, poultry, horse ranch, etc	2	1%	3	2%	13	5%	3	1%
10	Impervious	13	5%	10	6%	24	9%	11	4%
11	Undeveloped	154	57%	68	39%	67	26%	183	67%
12	Native/mountain	7	2%	2	1%	1	0%	1	0%
Total		273	100%	174	100%	258	100%	274	100%

1. Drainage areas are for the valley flow exclude mountain areas.

Table 2-7
Hydrologic Properties of Each Land Use Type

WEI Land Use Code	Land Use Type	Percent Impervious	AMC	Curve Number			
				Soil Type			
				A	B	C	D
1	Low Density Residential	30	2	32	56	69	75
2	Medium Density Residential	50	2	32	56	69	75
3	High Density Residential	75	2	32	56	69	75
4	Commercial	90	2	32	56	69	75
5	Industrial	90	2	32	56	69	75
6	Orchards and Vineyards	2	2	39	62	75	81
7	Irrigated Cropland and Improved Pasture Land, Golf course	2	2	53	70	80	85
8	Parks, schools	80	2	39	61	74	80
9	Dairy, poultry, horse ranch, etc	0	2	1	1	1	1
10	Impervious	100	2	98	98	98	98
11	Undeveloped	2	2	78	86	91	93
12	Native/mountain	2	2	47	67	78	83

AMC - Antecedent moisture condition

Table 2-8
USGS Surface Water Gages in the Study Area

Station Number	Station Name	Drainage Area (sq mile)	Elevation (ft)	Recording Period	
				Start	End
Used for Boundary Inflow					
11051500	Santa Ana River Near Mentone	210	1,984	1896	2006
11051501	Santa Ana River Near Mentone + Canals	210	1,984	1912	2006
11054000	Mill Creek Near Yucaipa	42	2,916	1918	1986
11055500	Plunge Creek Near East Highlands	17	1,590	1919	2006
11055501	Plunge Creek Near East Highlands and Canals	17	1,590	1951	2006
11055800	City Creek Near Highland	20	1,580	1919	2006
11058500	E Twin Creek Near Arrowhead Springs	9	1,590	1920	2000
11062000	Lytle Creek Near Fontana	47	2,380	1918	2000
11063510	Cajon Cr Below Lone Pine Cr Near Keenbrook	57		1971	2000
11063680	Devil Cyn Creek Near San Bernardino	5	1,900	1920	2000
11067000	Day Creek Near Etiwanda	5	2,870	1928	1972
11073470	Cucamonga Creek Near Upland	10	2,600	1929	1975
Used for Calibration					
11057500	San Timoteo Creek Near Loma Linda	125	1,010	1954	2006
11059300	Santa Ana River at E-Street	541	940	1939	2006
11066460	Santa Ana River at MWD Crossing	852	685	1970	2006
11072100	Temescal Creek At Main St	224	600	1980	2006
11073360	Chino Creek at Schaefer Avenue	49	685	1969	2006
11073495	Cucamonga Creek Near Mira Loma	76	660	1968	2006
11074000	Santa Ana River Below Prado Dam	1,490	449	1940	2006

Table 2-9
Statistics of Calibration

Station Number	Station Name	Model Performance Statistics Based on Monthly Flow Data			
		R-square[1]	RMSE[2] (acre-ft/mo)	RMSE Percent of Average Flow[3]	NSE[4]
11057500	San Timoteo Creek Near Loma Linda	0.87	22.10	12.5%	0.76
11059300	Santa Ana River at E-Street	0.93	64.62	1.5%	0.92
11066460	Santa Ana River at MWD Crossing	0.93	104.86	1.0%	0.84
11072100	Temescal Creek At Main St	0.77	45.09	2.2%	0.71
11073360	Chino Creek at Schaefer Avenue	0.84	38.33	2.6%	0.84
11073495	Cucamonga Creek Near Mira Loma	0.79	62.35	1.6%	0.74
11074000	Santa Ana River Below Prado Dam	0.93	154.50	0.6%	0.92

1 -- R-square: Correlation Coefficient 0:1

2 -- RMSE: Root Mean Square Error

3 -- RMSE/Q - Root Mean Square Error divided by the mean monthly discharge at the measurement station over the calibration period

4 -- NSE: Nash-Sutcliffe Efficiency - ∞:1

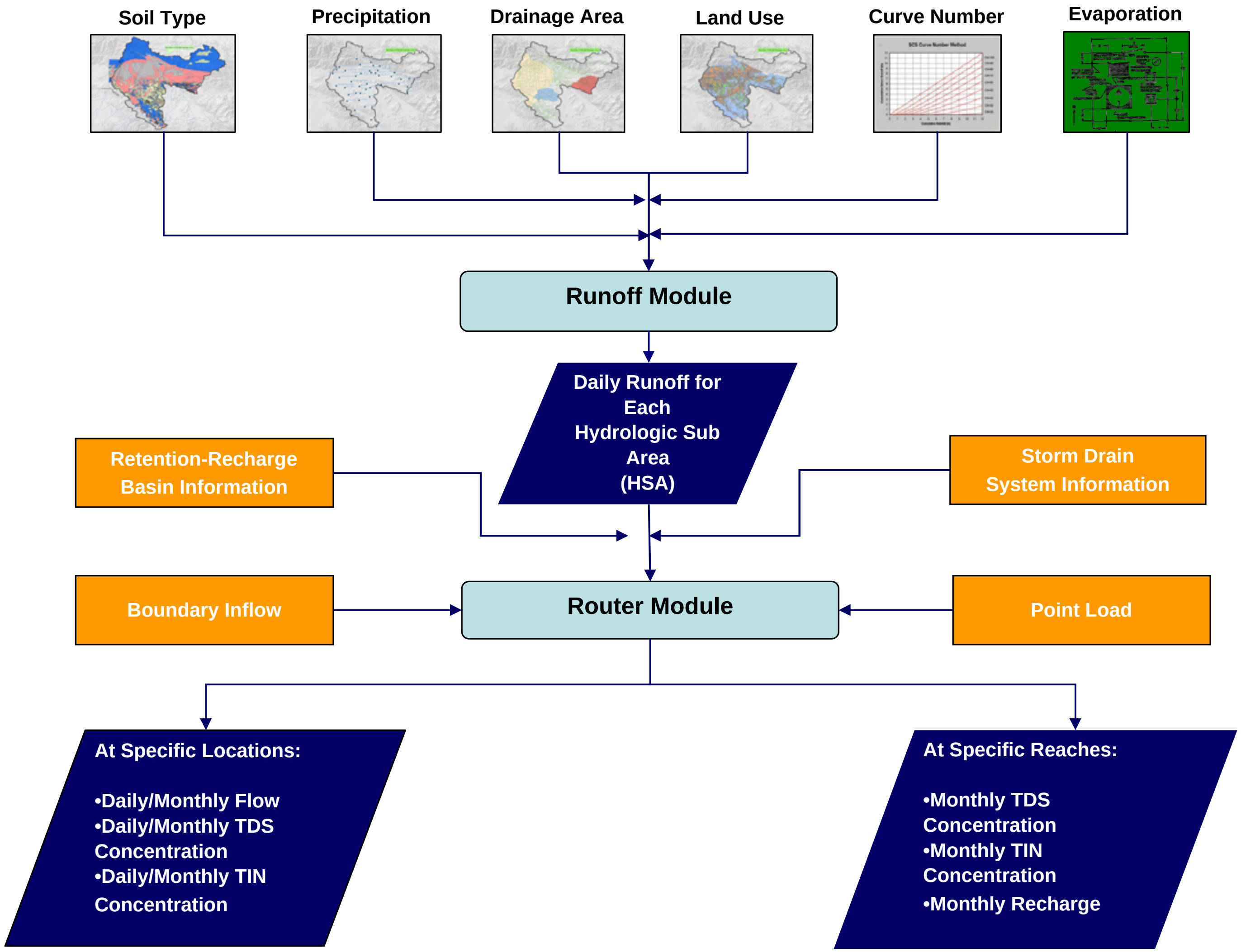


Figure 2-1
Organization of the Wasteload Allocation Model

Figure 2-2
Graphical Representation of the SCS Method Rainfall Runoff Process

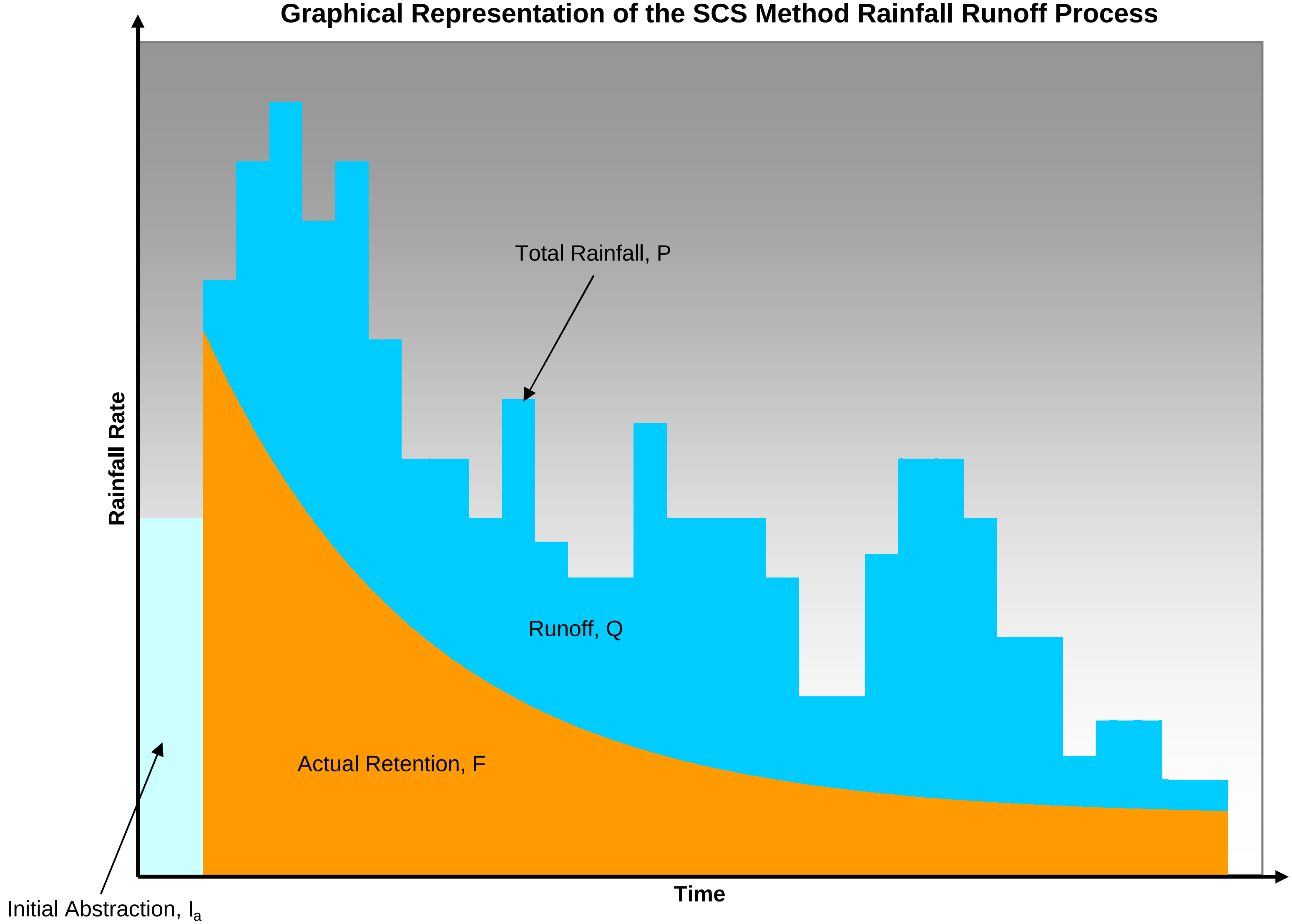
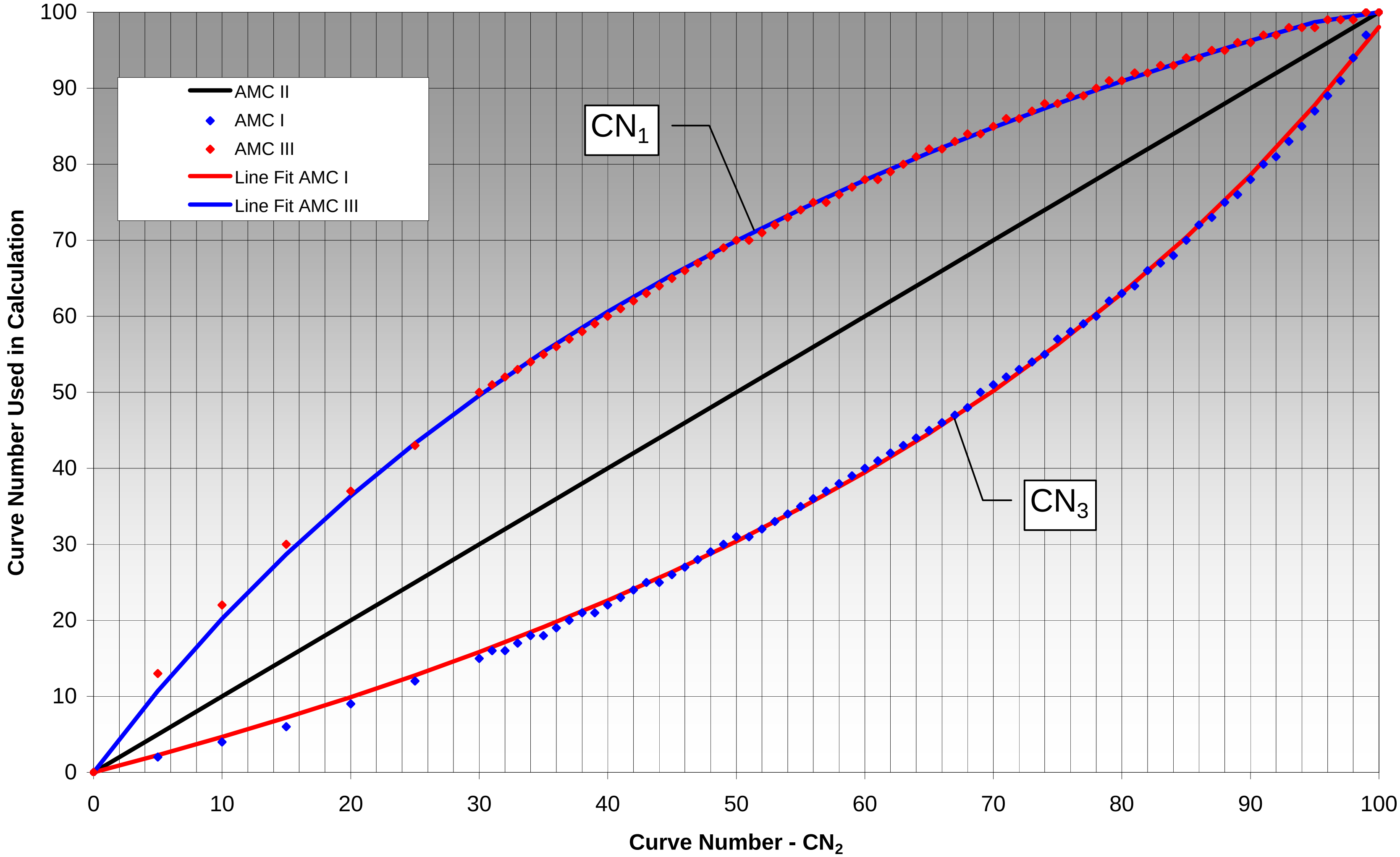


Figure 2-3
Variation of Curve Number Due to Antecedent Soil Moisture Condition (AMC)



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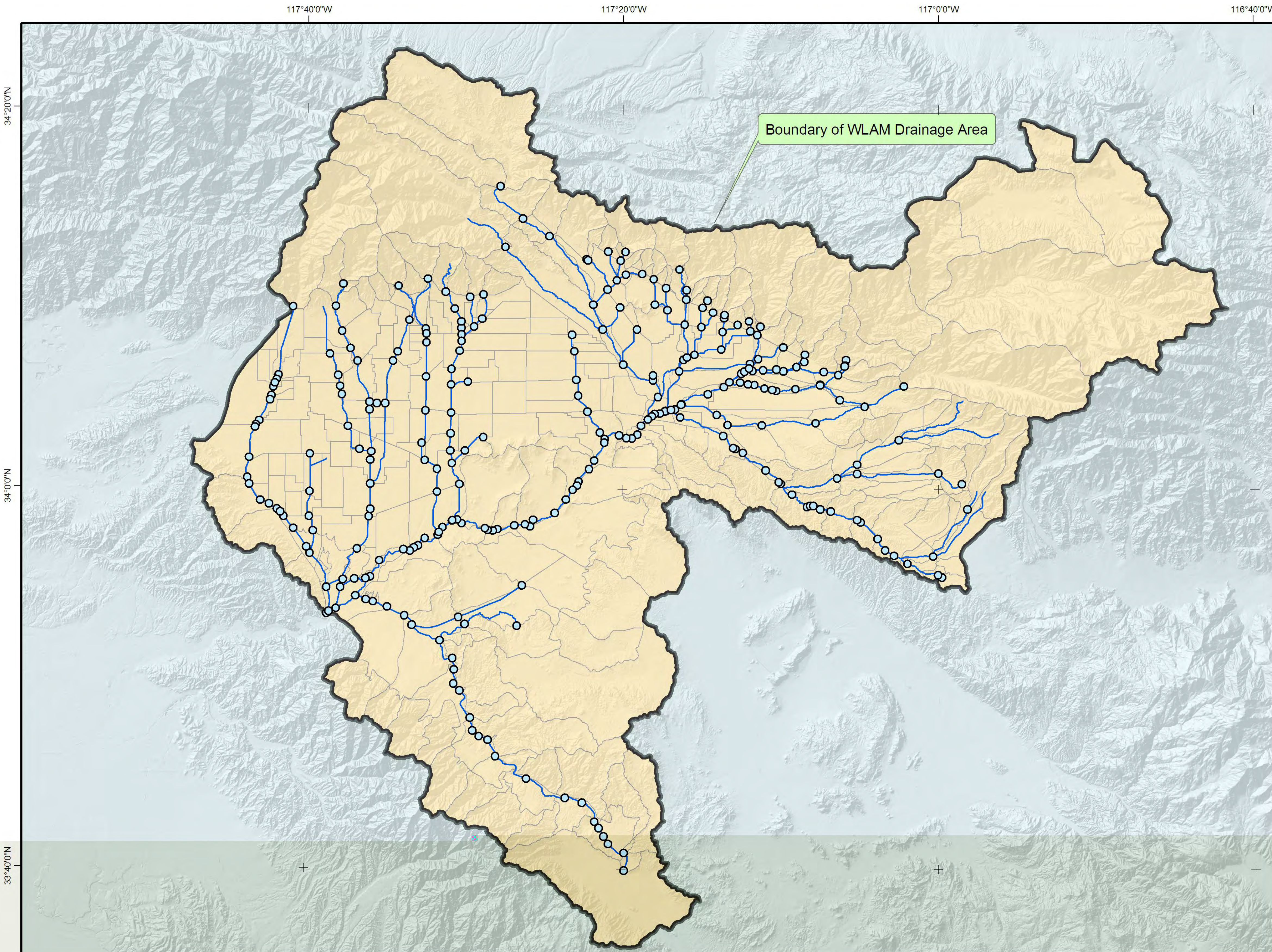
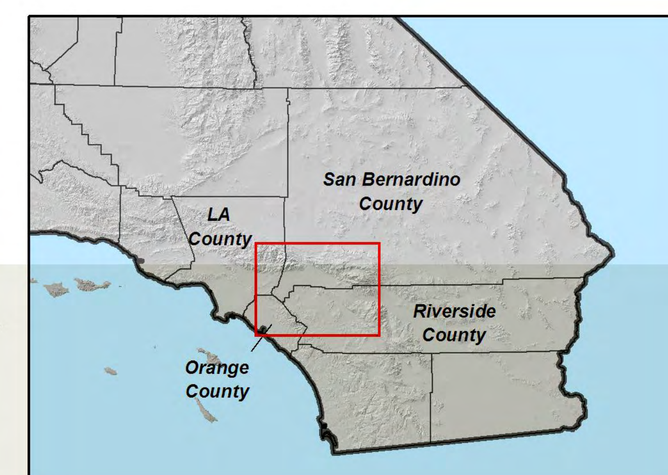


Main Features

- WLAM Hydrologic Simulation Areas
- R4 Routing Node
- R4 Routing Link



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0 5 10 15 Miles

0 10 20 30

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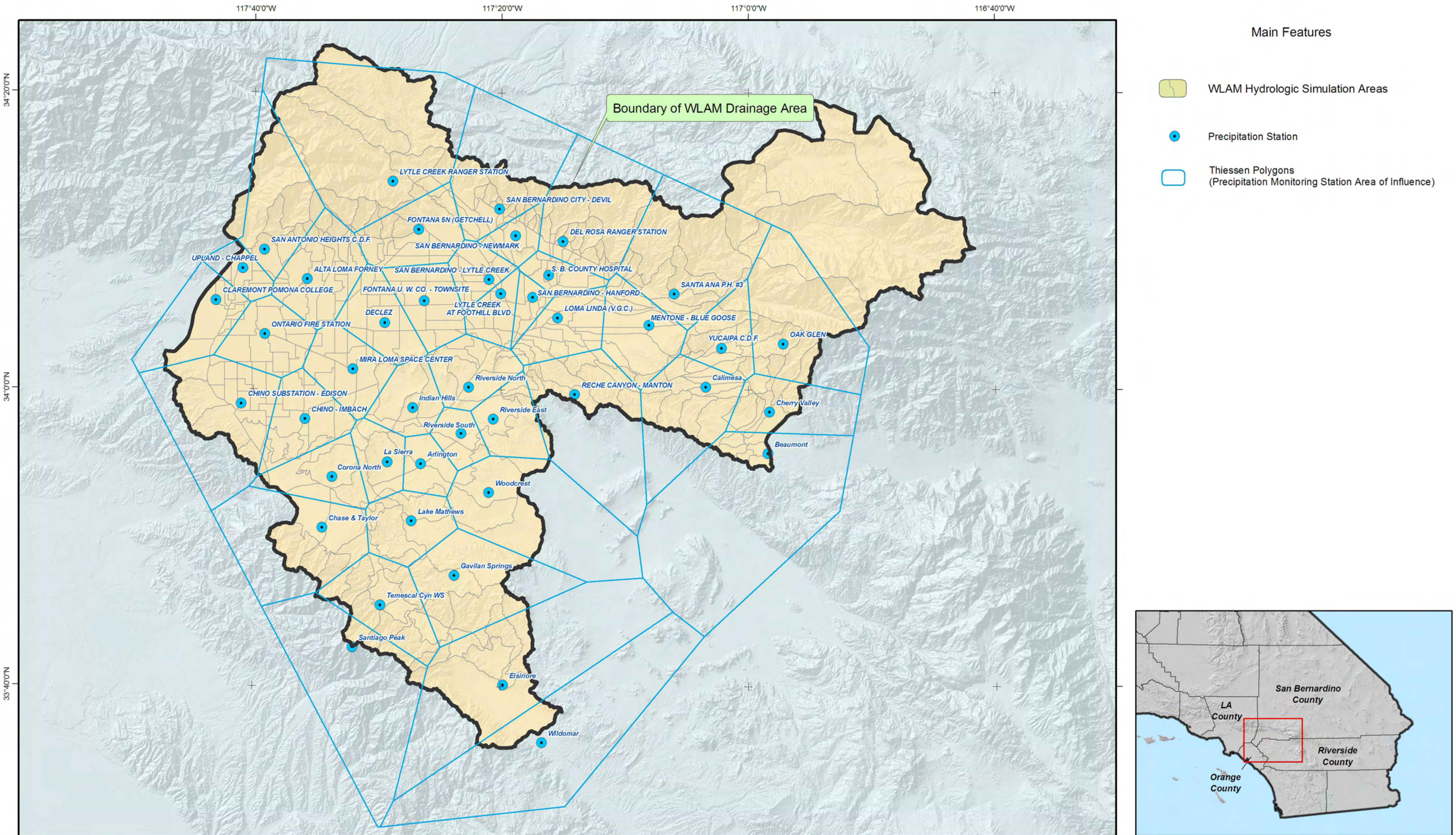
Location of Hydrologic Sub Areas, Model Links and Nodes

Figure 2-4



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0 5 10 15 Miles
0 10 20 30 KM

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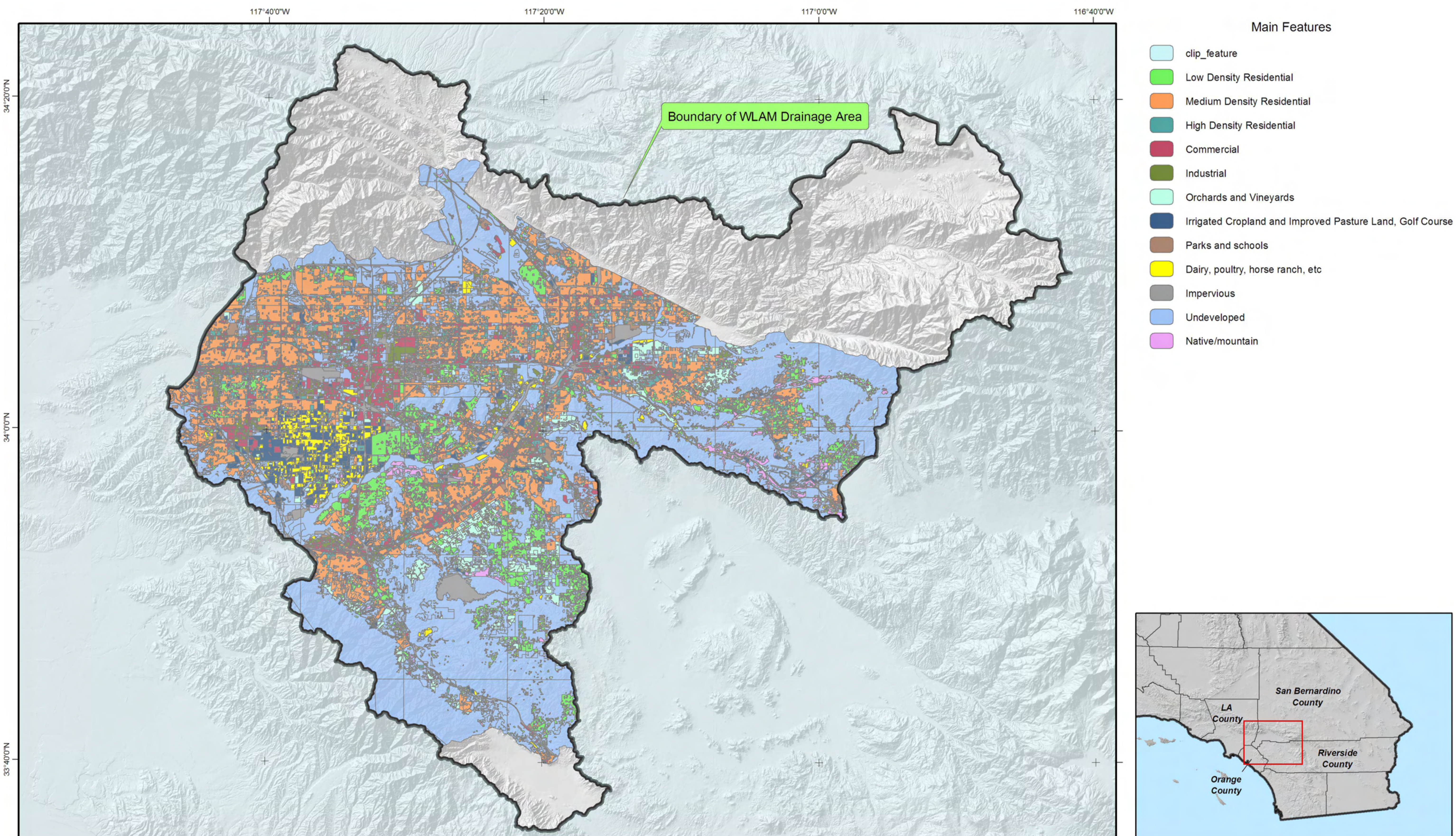
Location of Hydrologic Sub-Areas, Rainfall Monitoring Stations, and Thiessen Polygons

Figure 2-5



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0 5 10 15 Miles

0 10 20 30 KM

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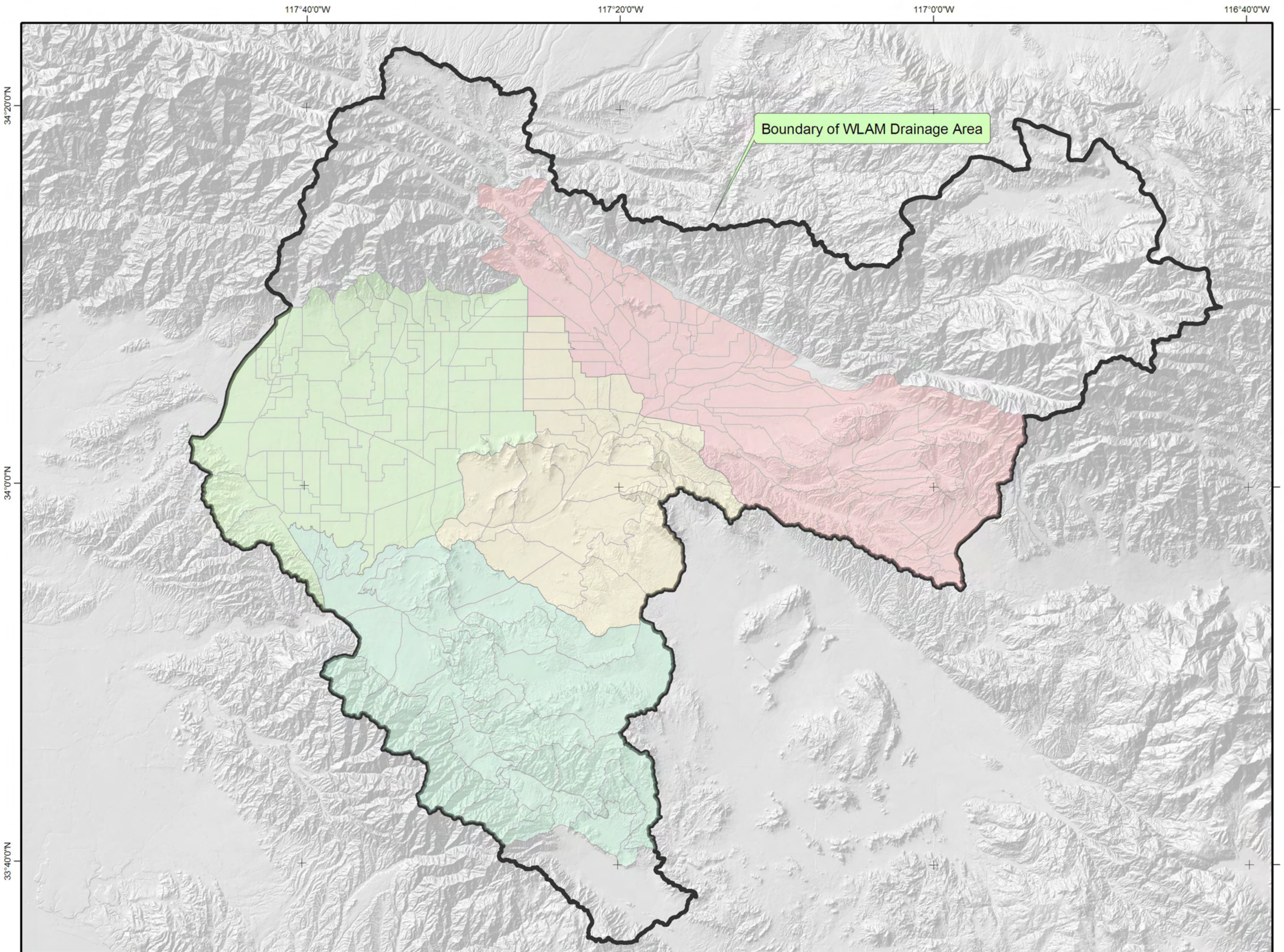
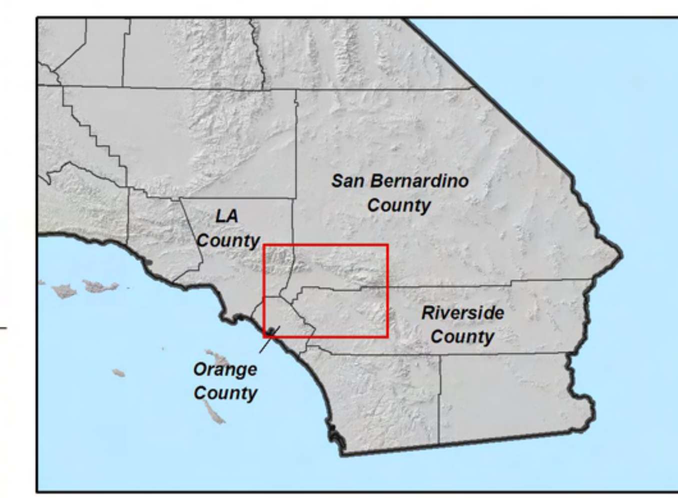
2001 Land Uses in the Upper Santa Ana Watershed

Figure 2-6



Main Features

- Drainage Area Upstream of E Street Gaging Station with WLAM Hydrologic Simulation Areas
- Drainage Area Between E Street Gaging Station and Riverside Narrows with WLAM Hydrologic Simulation Areas
- Chino Drainage Areawith WLAM Hydrologic Simulation Areas
- Temescal Prado Drainage Area with WLAM Hydrologic Simulation Areas



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0 5 10 15 Miles
0 10 20 30 KM

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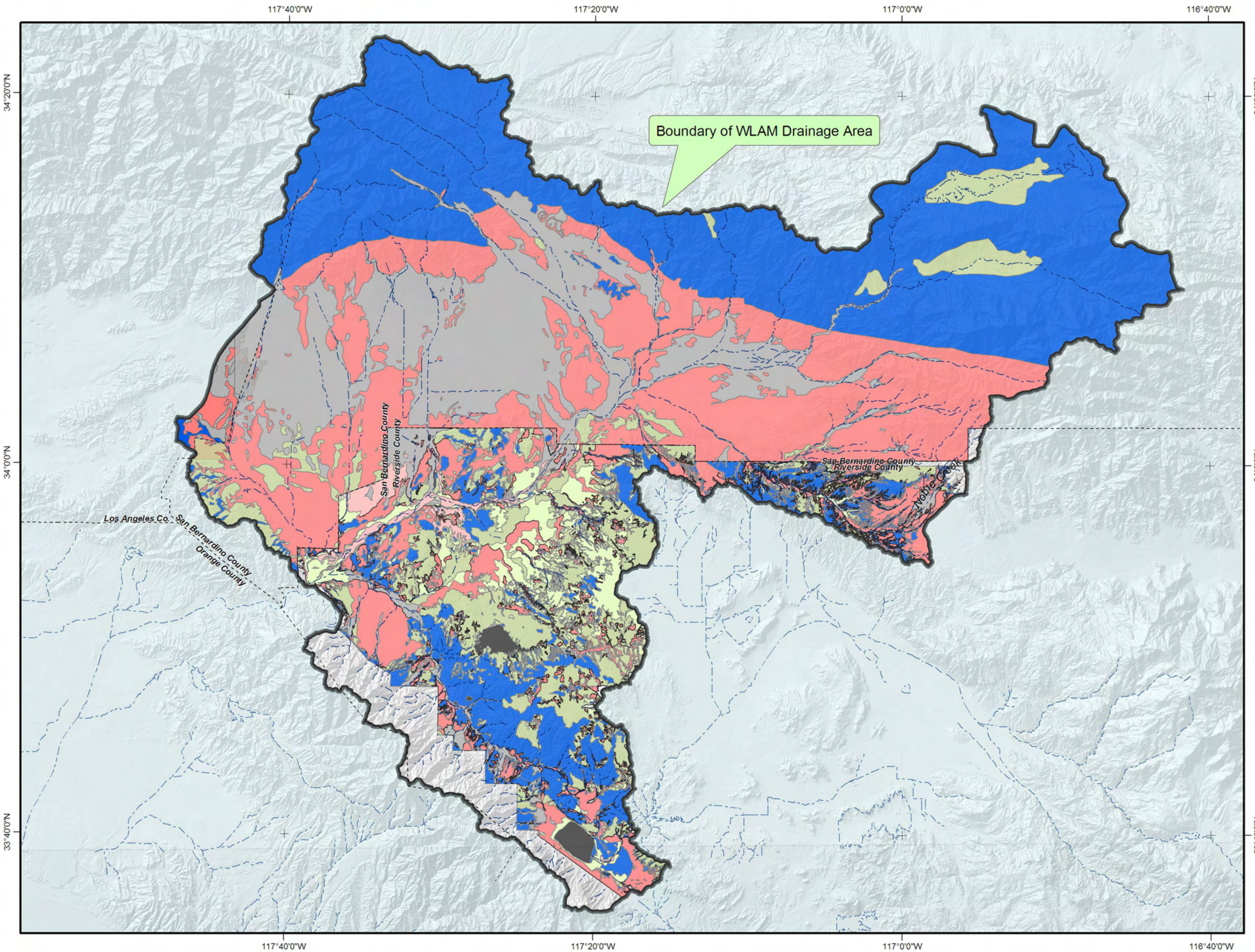
Summary Land Use Drainage Area in the Valley Floor of the Modeling Domain

Figure 2-7



Soil Conservation Service (SCS) Types

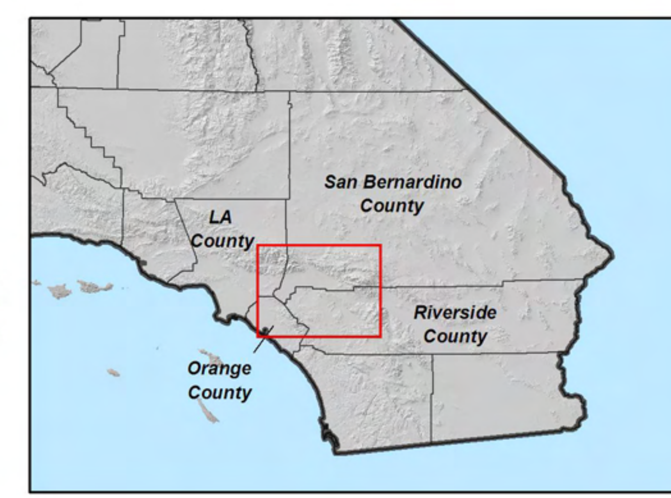
- **A** — Low runoff potential. Soils having high infiltration rates even when thoroughly wetted and consisting chiefly of deep, well to excessively drained sands or gravels. These soils have a high rate of water transmission.
- **B** — Soils having moderate infiltration rates when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.
- **C** — Soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine texture. These soils have a slow rate of water transmission.
- **D** — High runoff potential. Soils having very slow infiltration rates when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission.

Hybrid Soil Types by Riverside County Flood Control District

- AB
- AC
- BC
- Water Body

Other Features

- WLAM Study Area Watershed
- Rivers, Creeks, and Flood Control Channels



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0 5 10 15 Miles
0 10 20 30 KM

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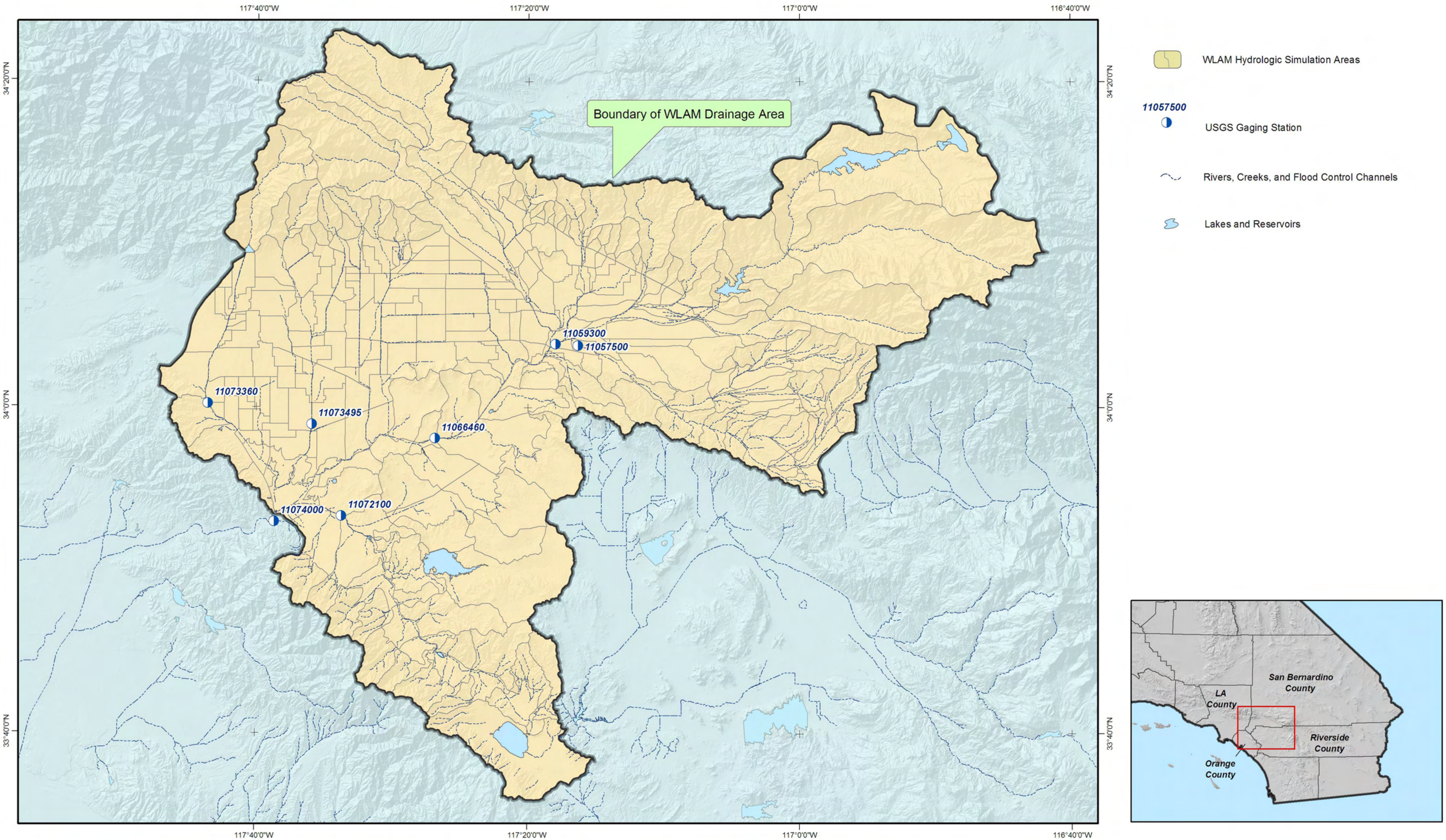
SCS Hydrologic Soil Map

Figure 2-8



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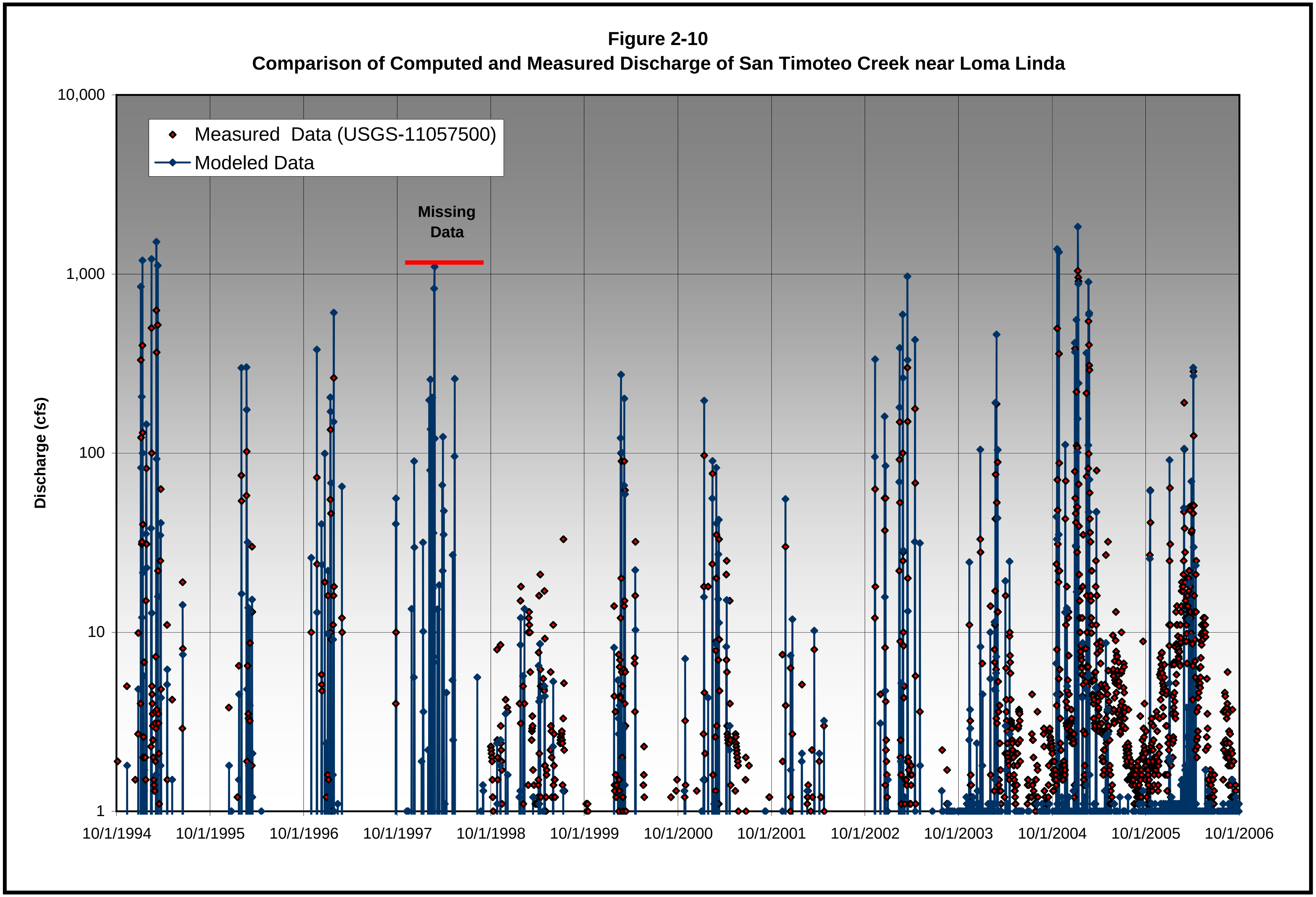
USGS Surface Water Monitoring Stations Used in Model Calibration

Figure 2-9



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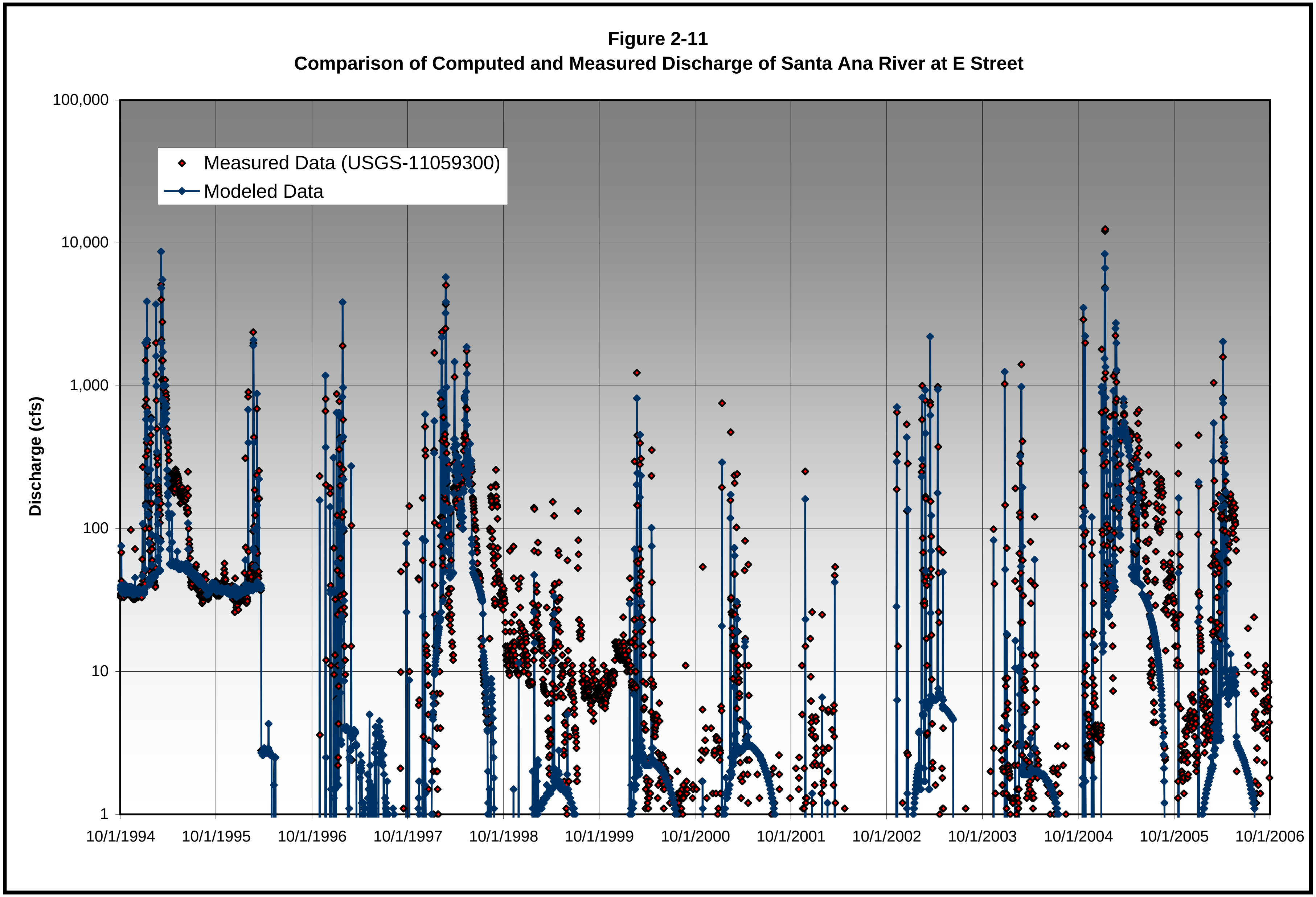

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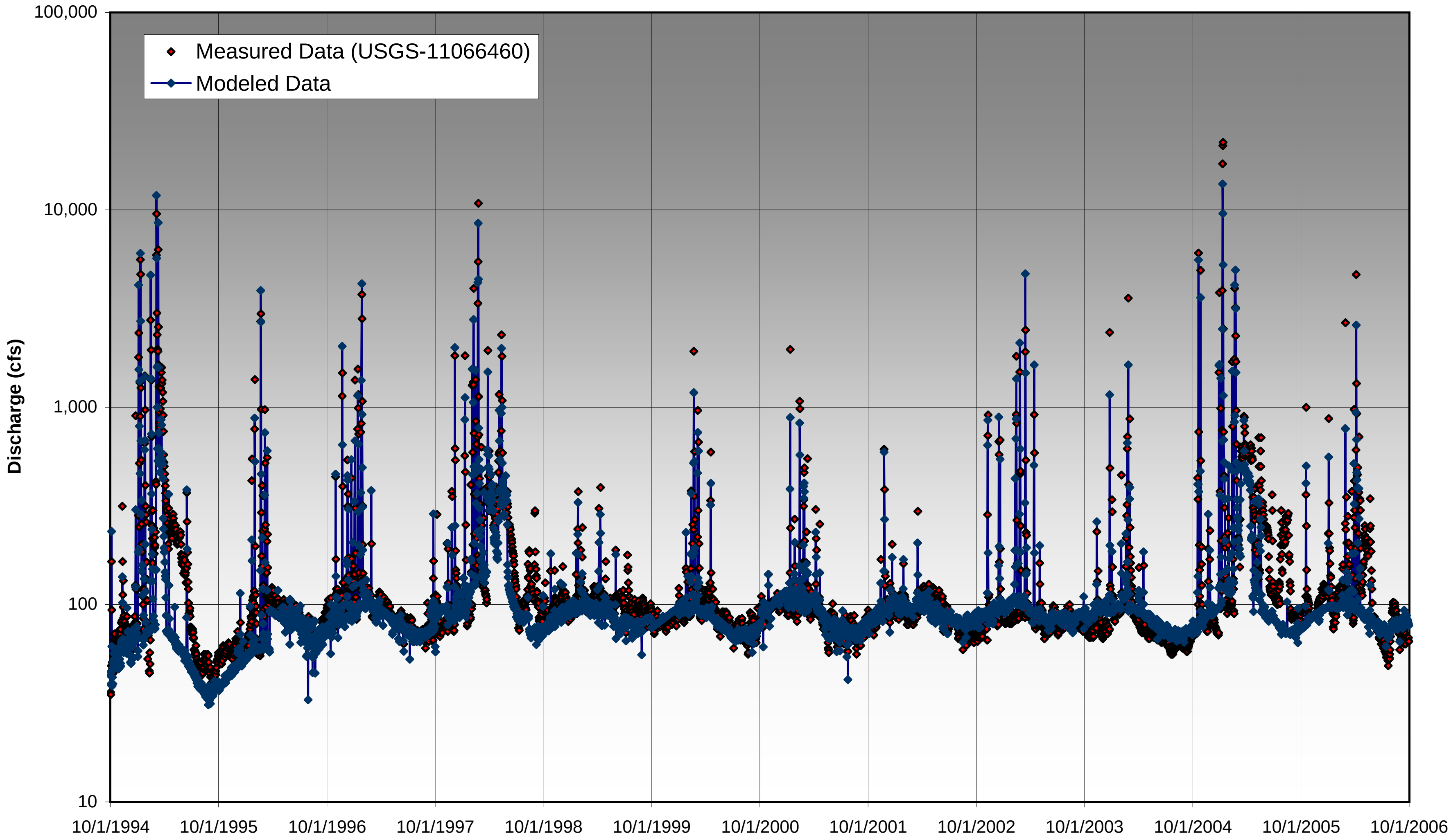
Figure 2-12
Comparison of Computed and Measured Discharge of Santa Ana River at MWD Crossing



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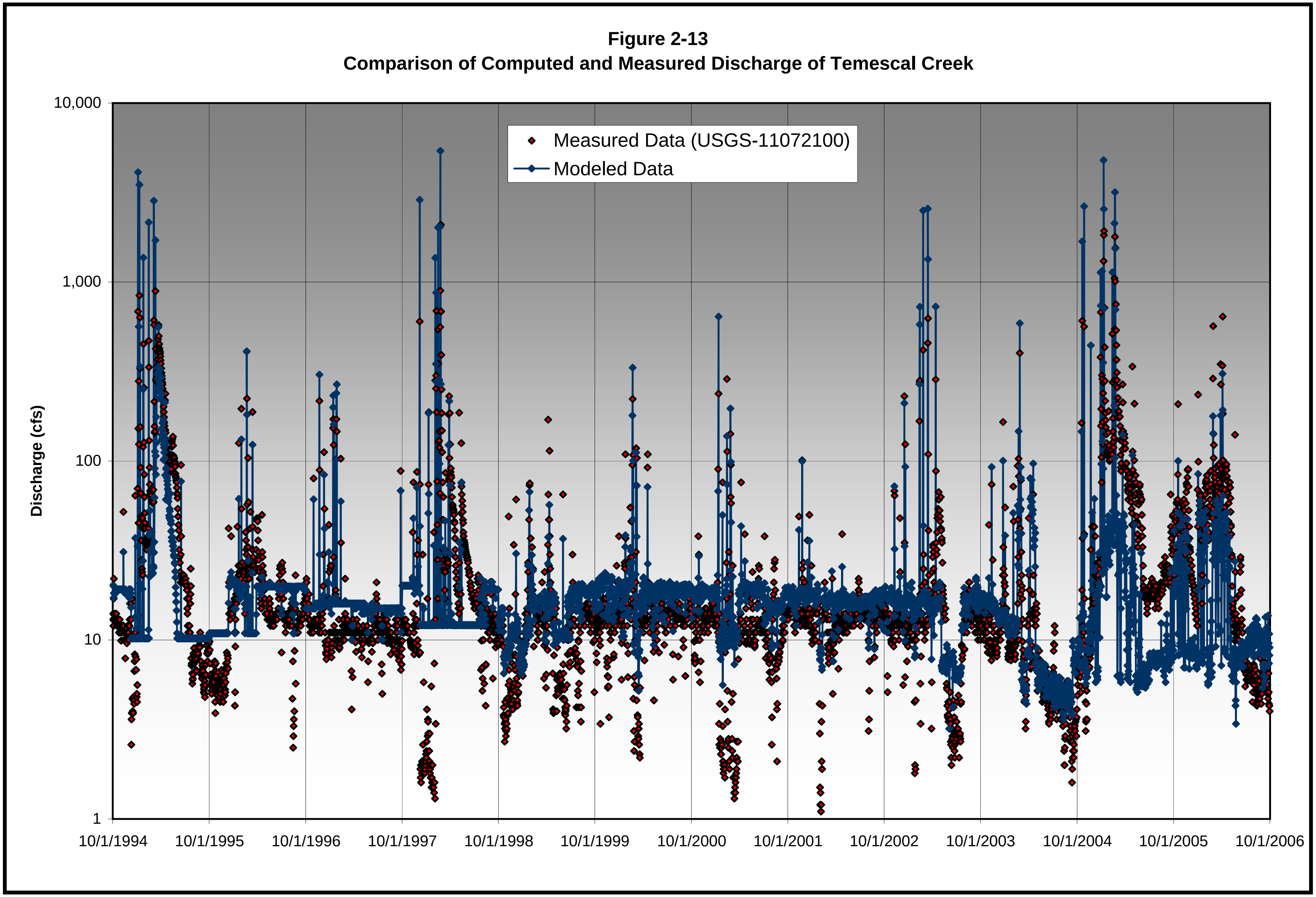

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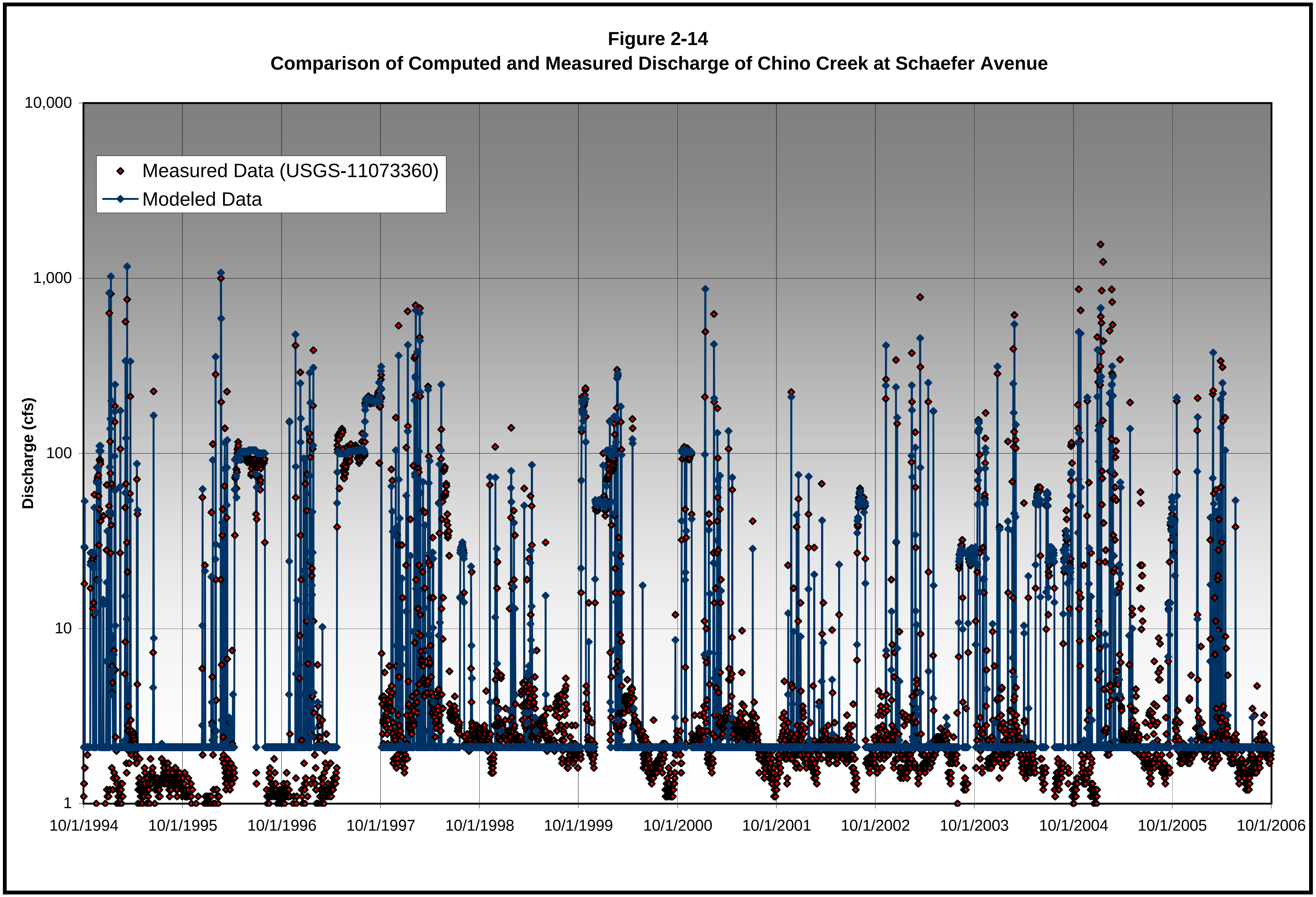

Figure 2-14
Comparison of Computed and Measured Discharge of Chino Creek at Schaefer Avenue
Measured Data (USGS-11073360)
Modeled Data
Discharge (cfs)
10,000
1,000
100
10
1
10/1/1994
10/1/1995
10/1/1996
10/1/1997
10/1/1998
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10/1/2004
10/1/2005
10/1/2006

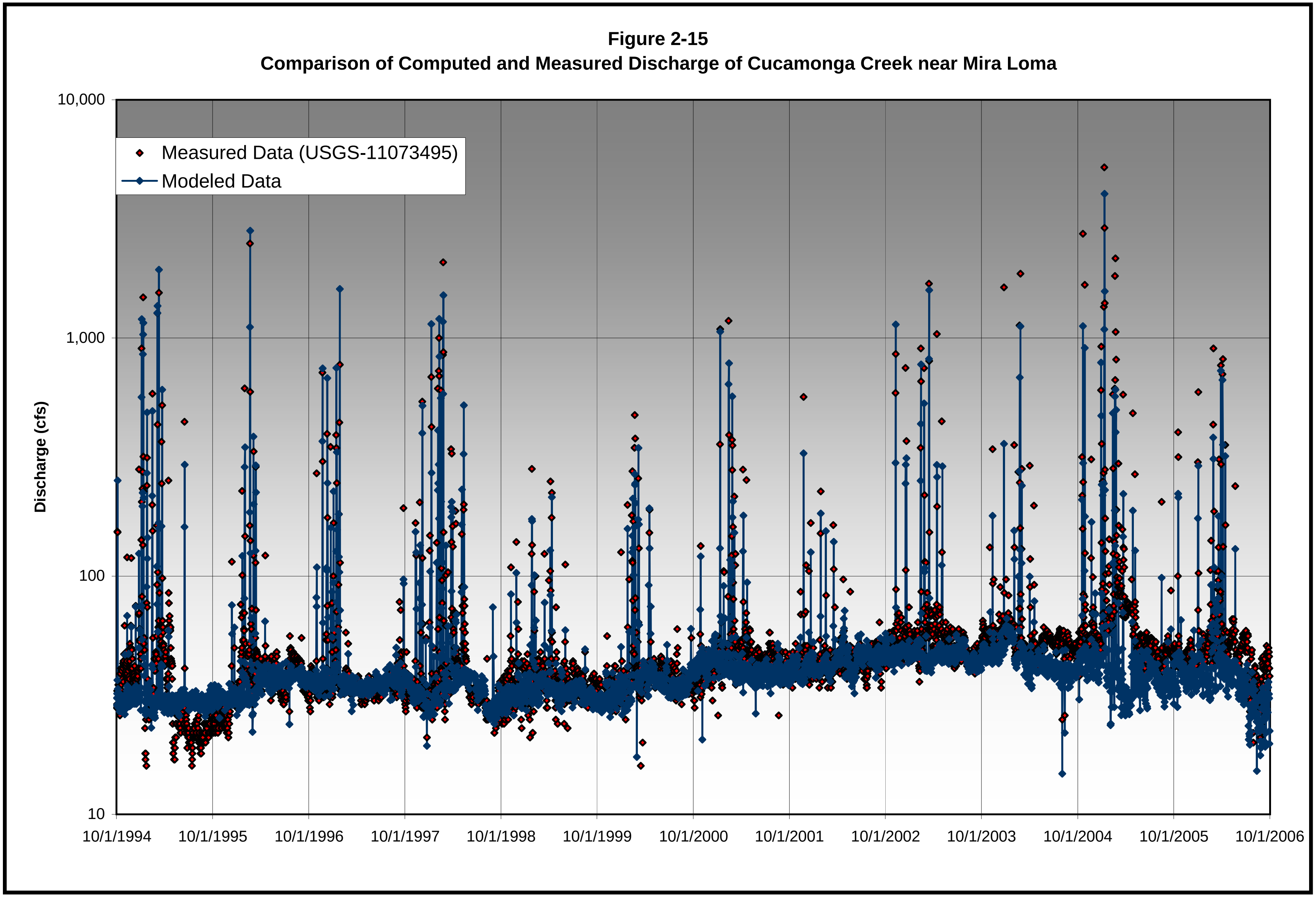

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Figure 2-16
Comparison of Computed and Measured Discharge of Santa Ana River into Prado Dam

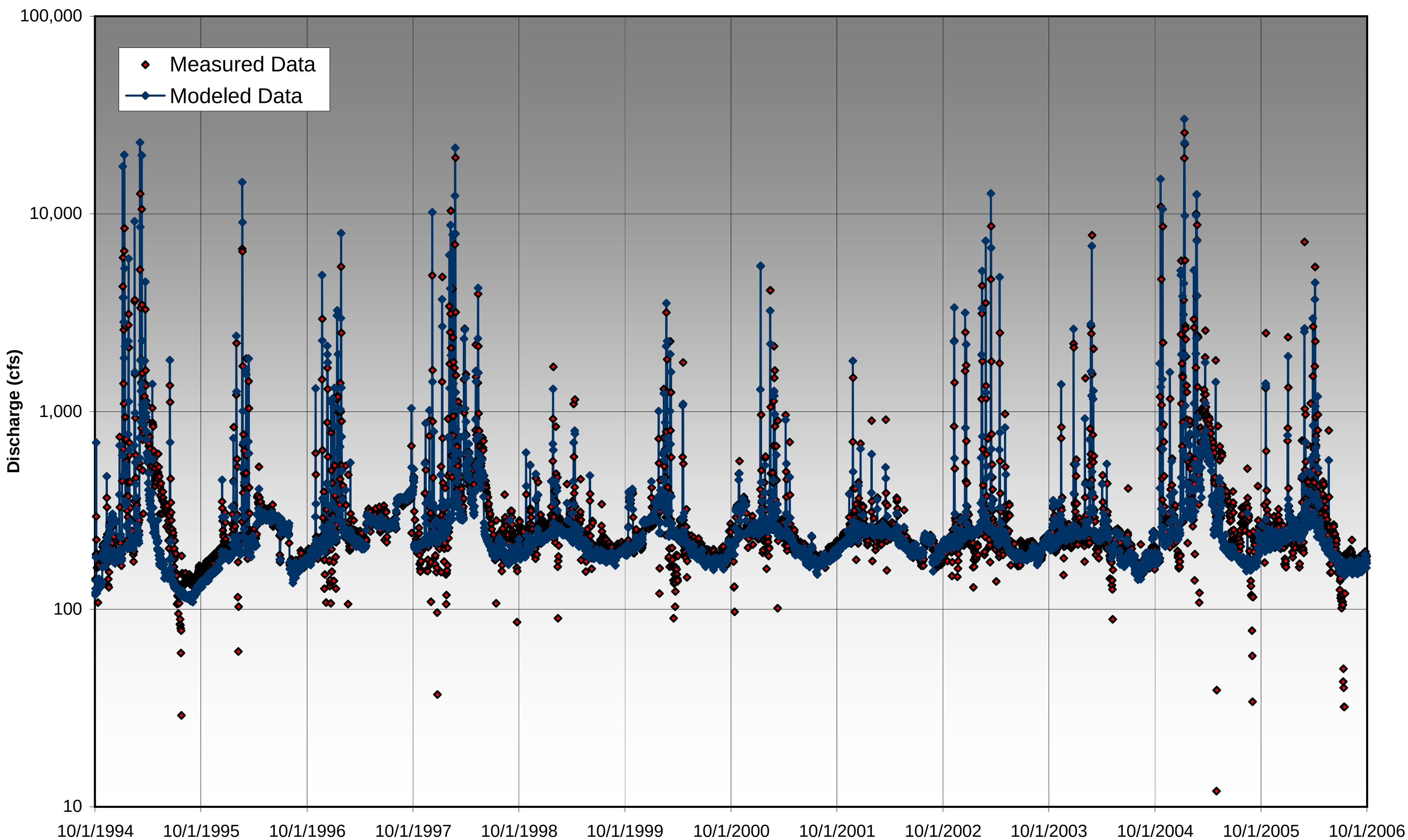

Figure 2-17a
Comparison of Computed and Measured Monthly Discharge at All Locations (All Discharges)

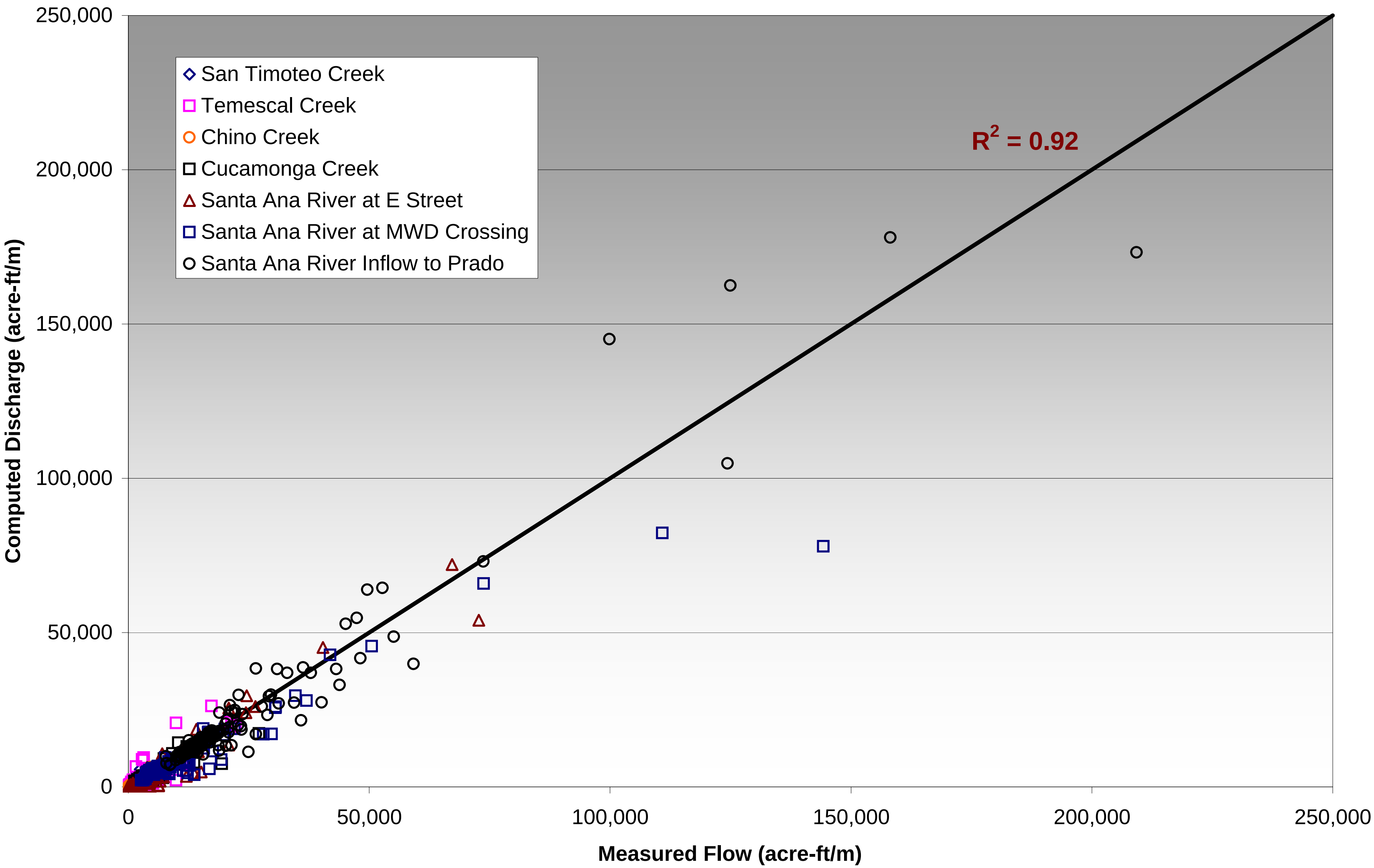

figure 2-17_rev

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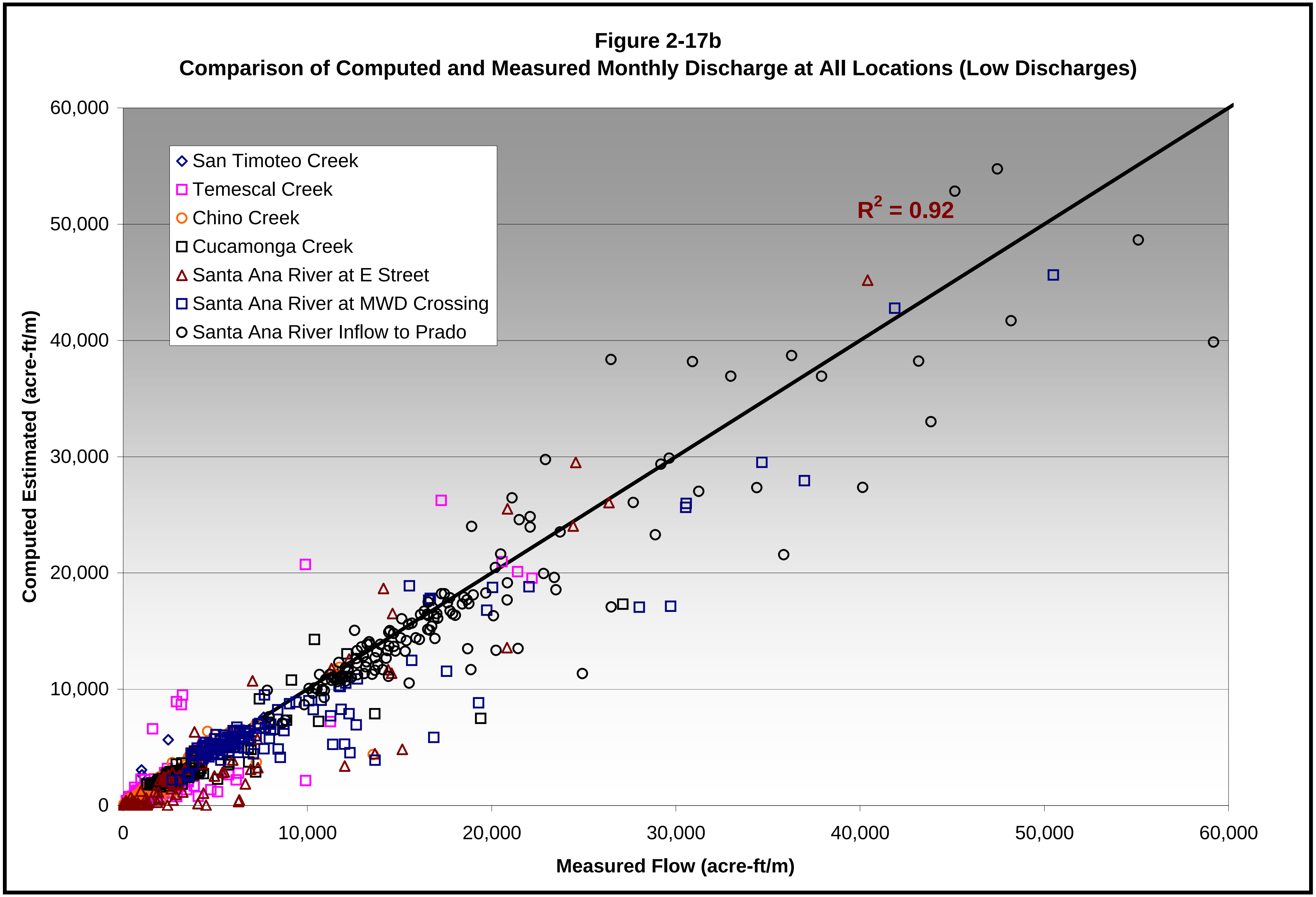

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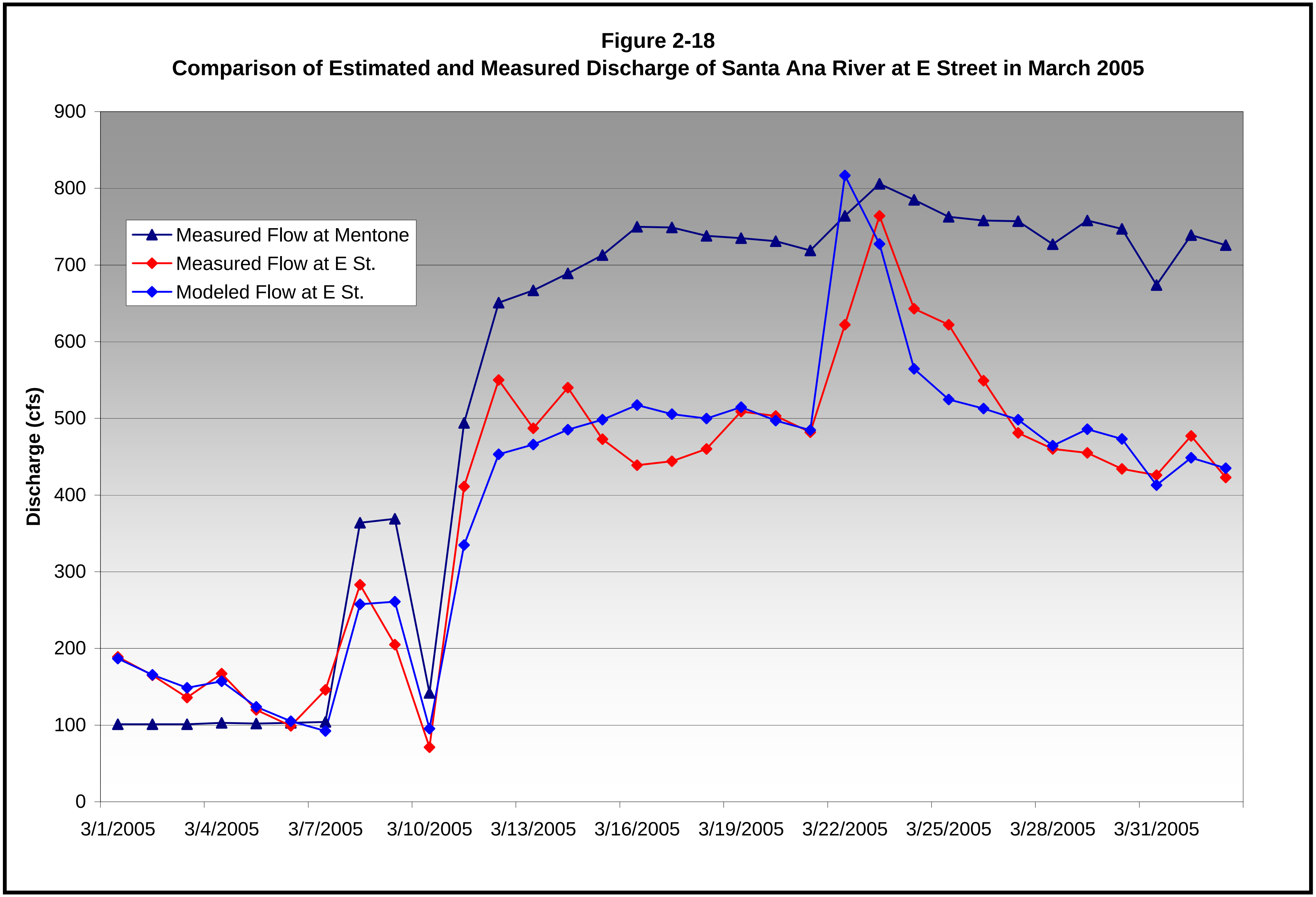

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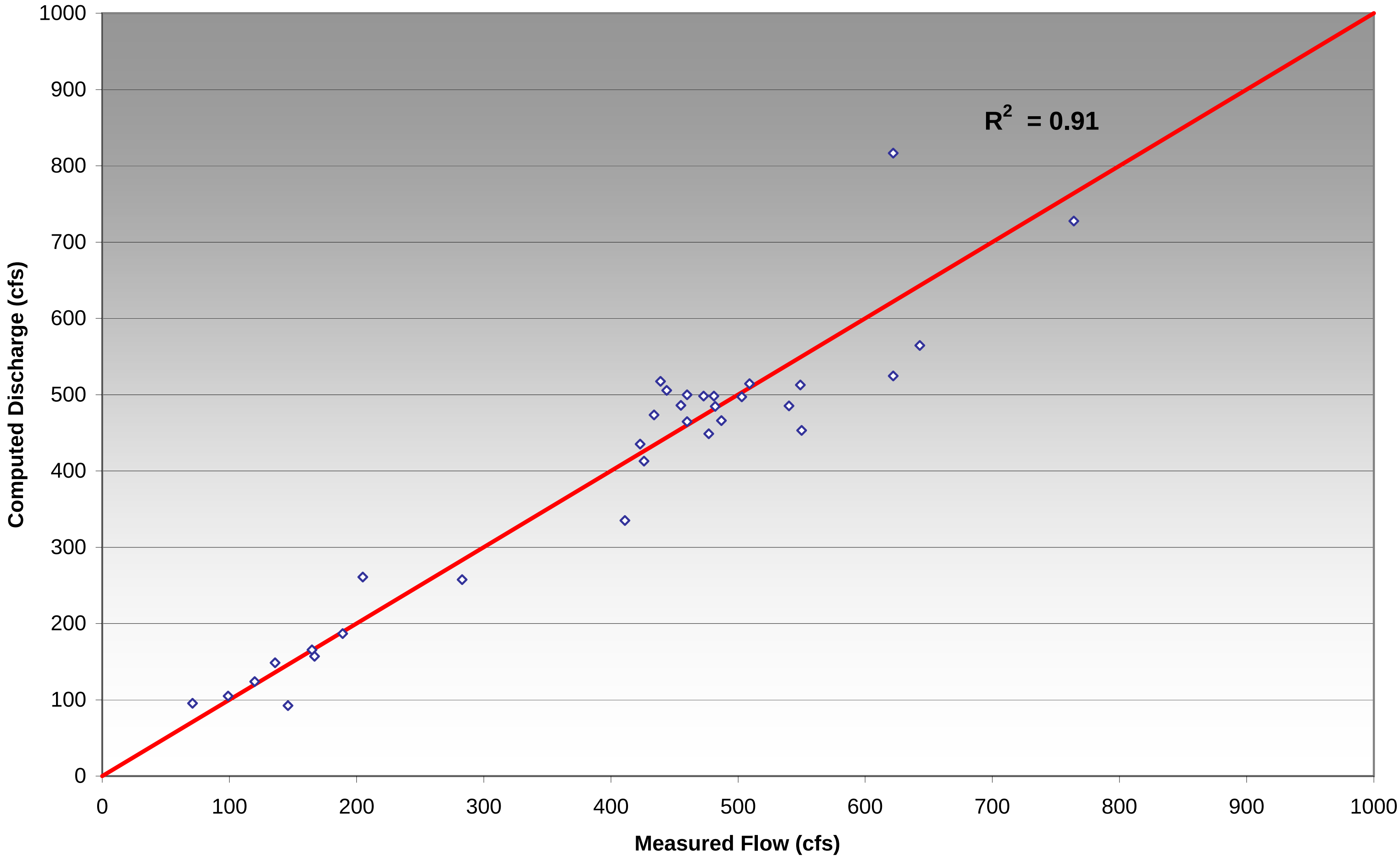
Figure 2-19
Scatter Plot of Calculated and Measured Discharge of Santa Ana River at E Street in March 2005



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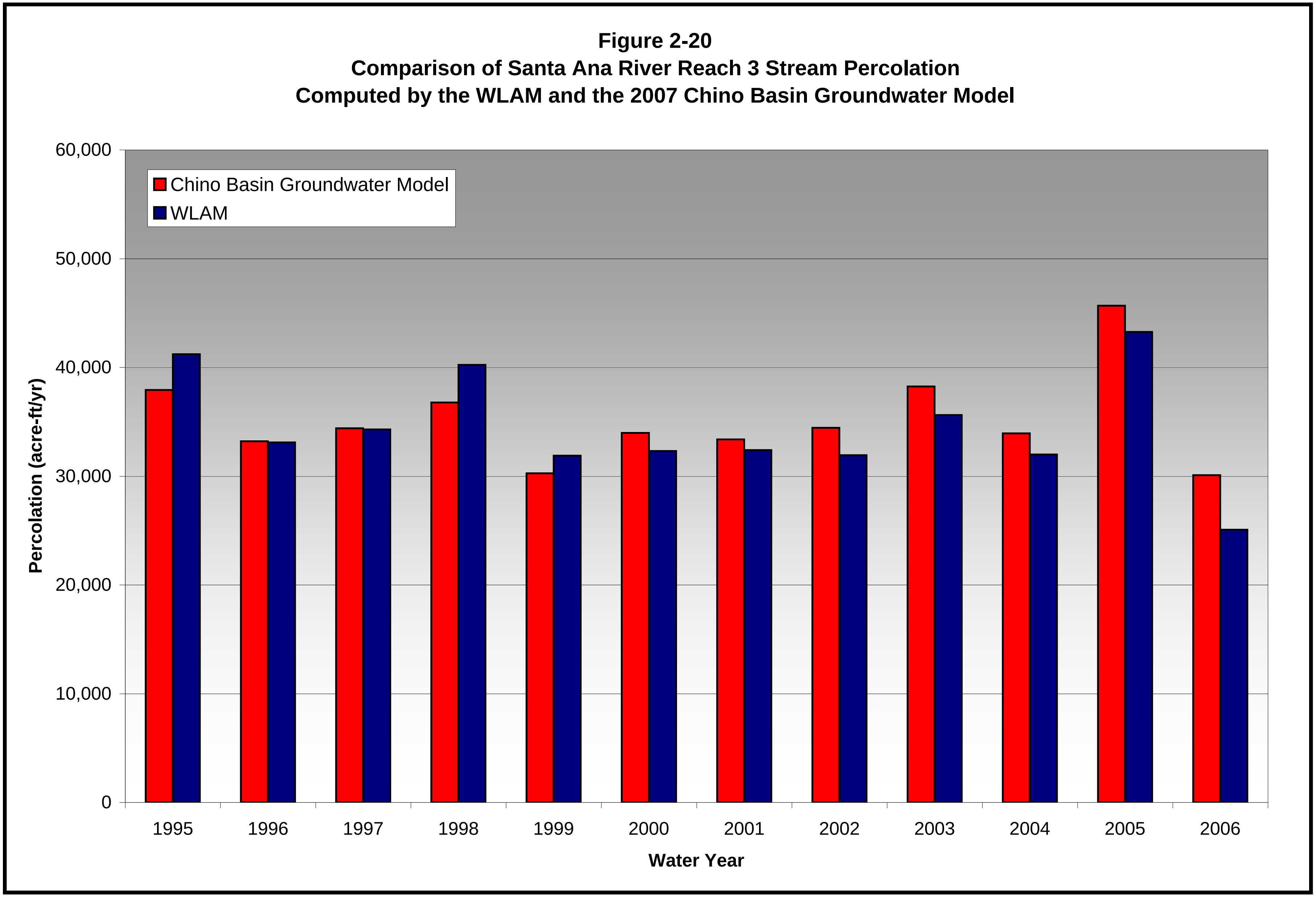

figure 2-20_2-21

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Figure 2-21
Scatter Plot of Santa Ana River Reach 3 Stream Percolation Computed by the WLAM and the 2007 Chino Basin Groundwater Model

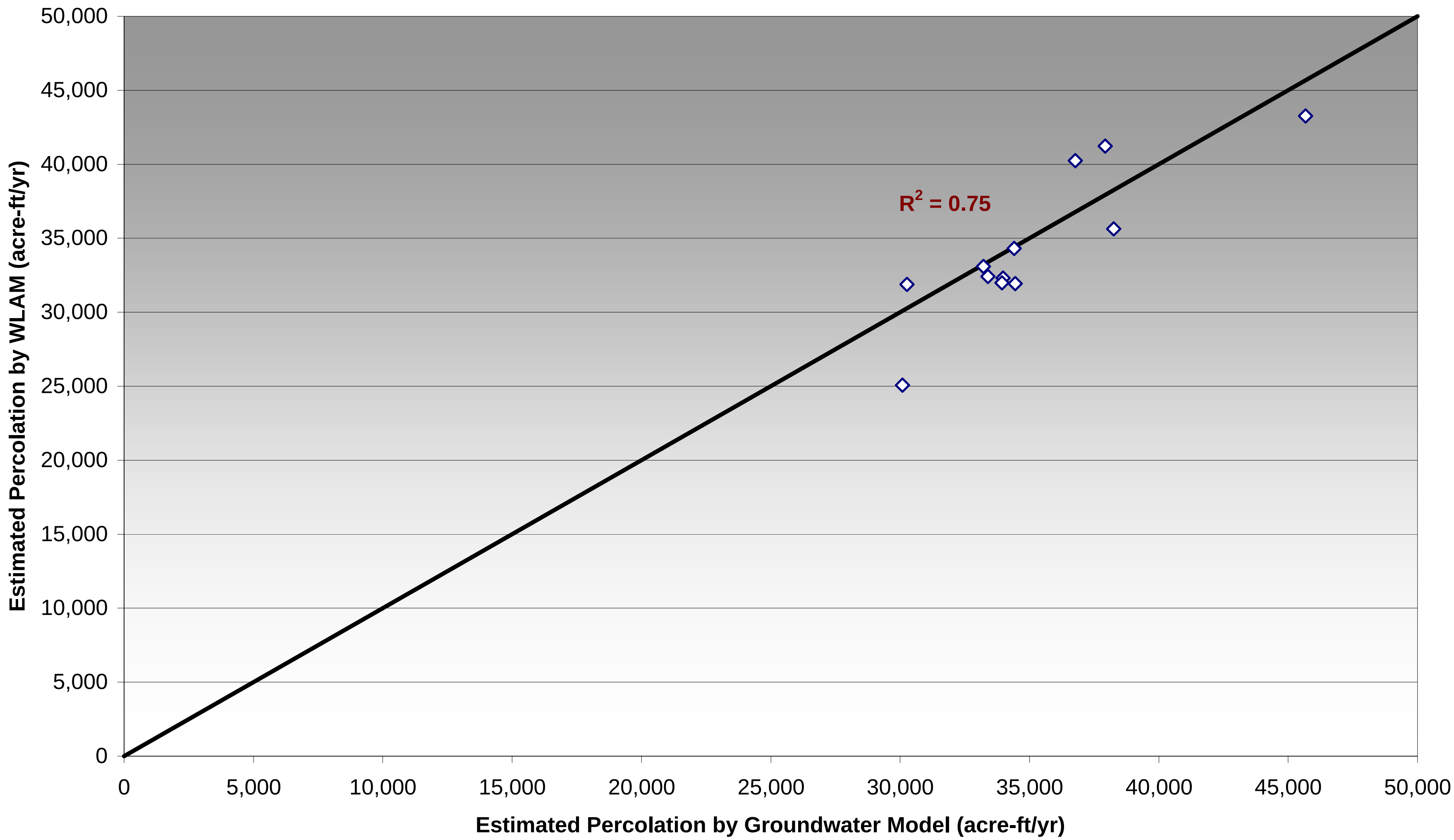

figure 2-20_2-21

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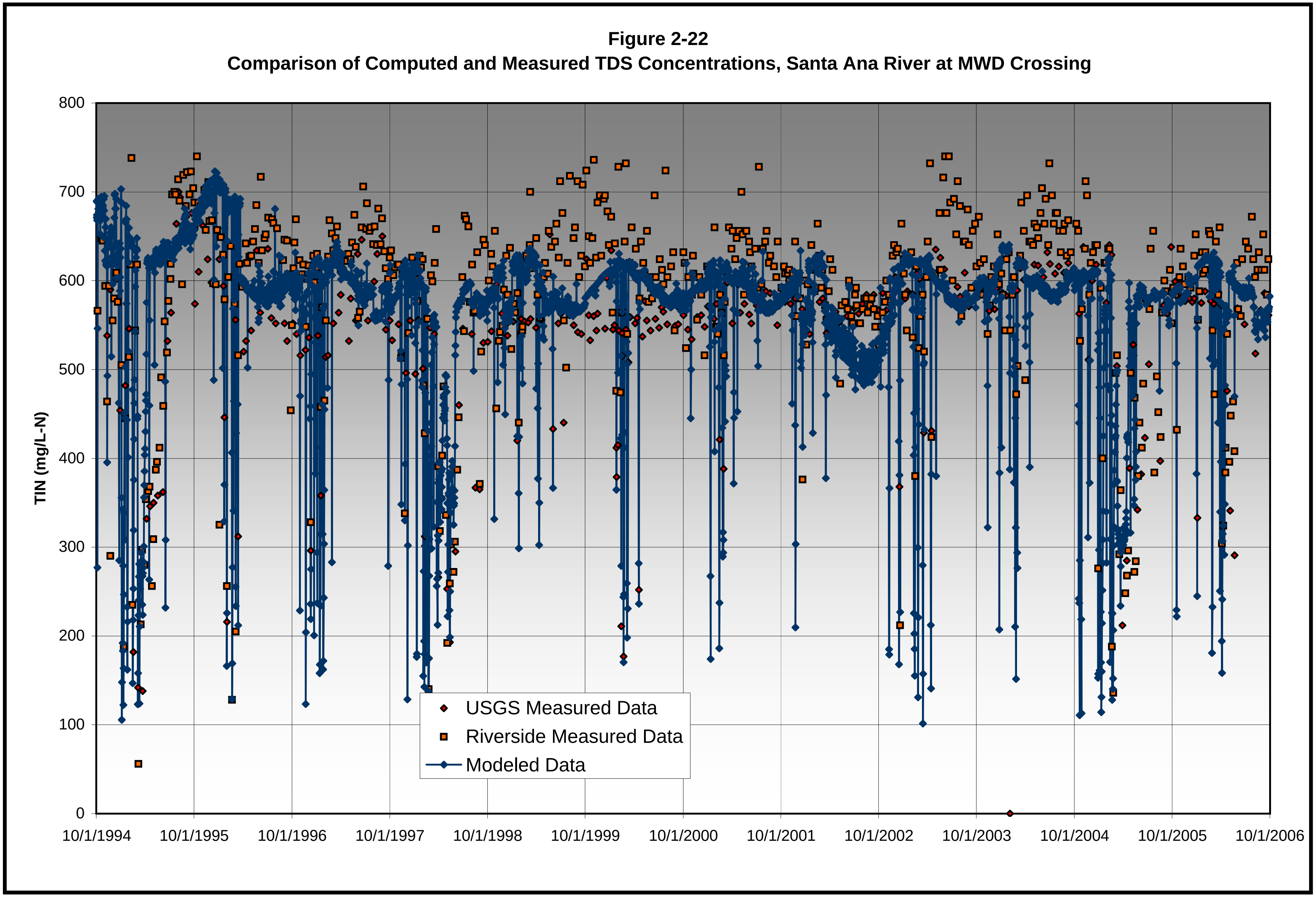

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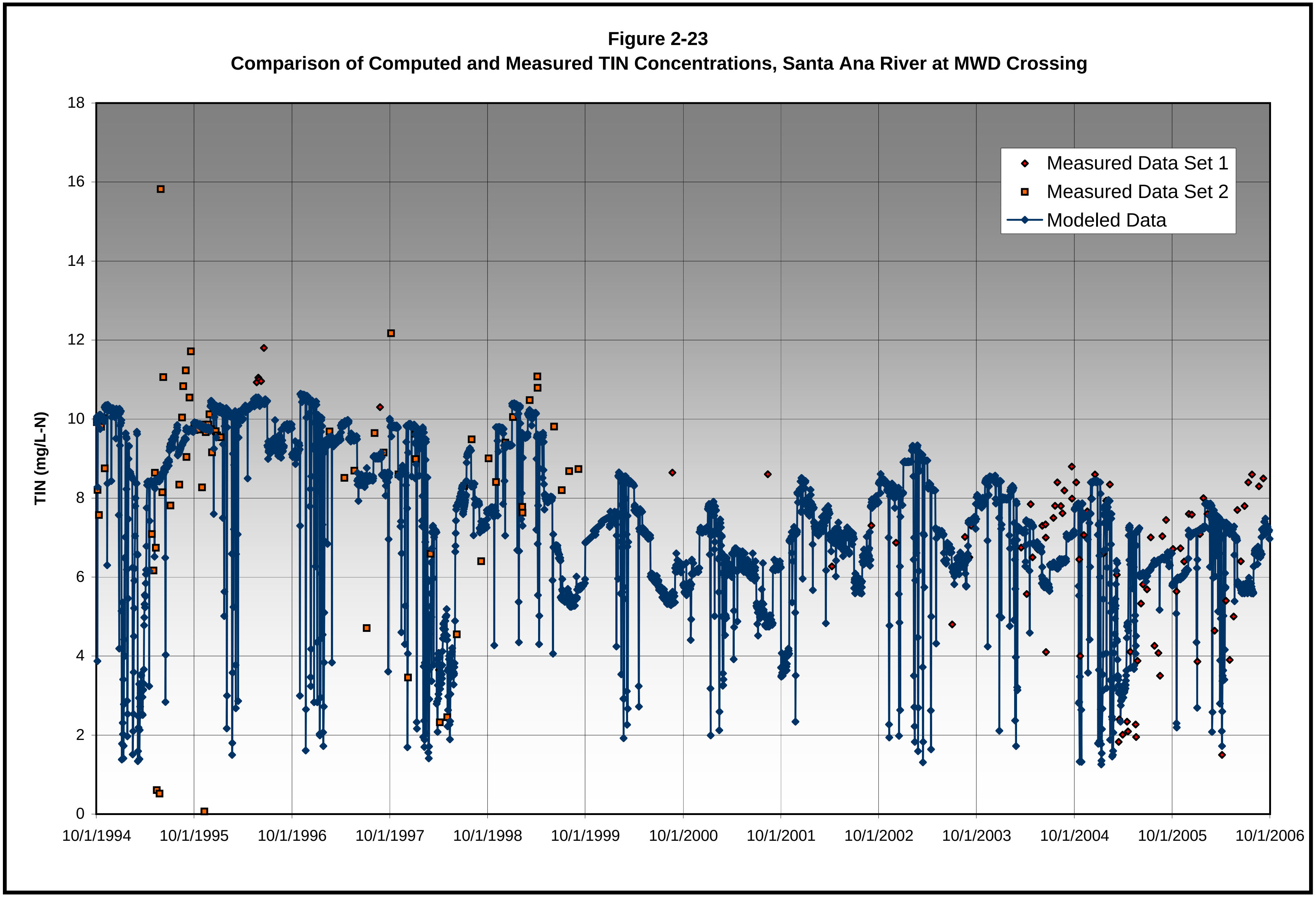


figure 2-22_2-25

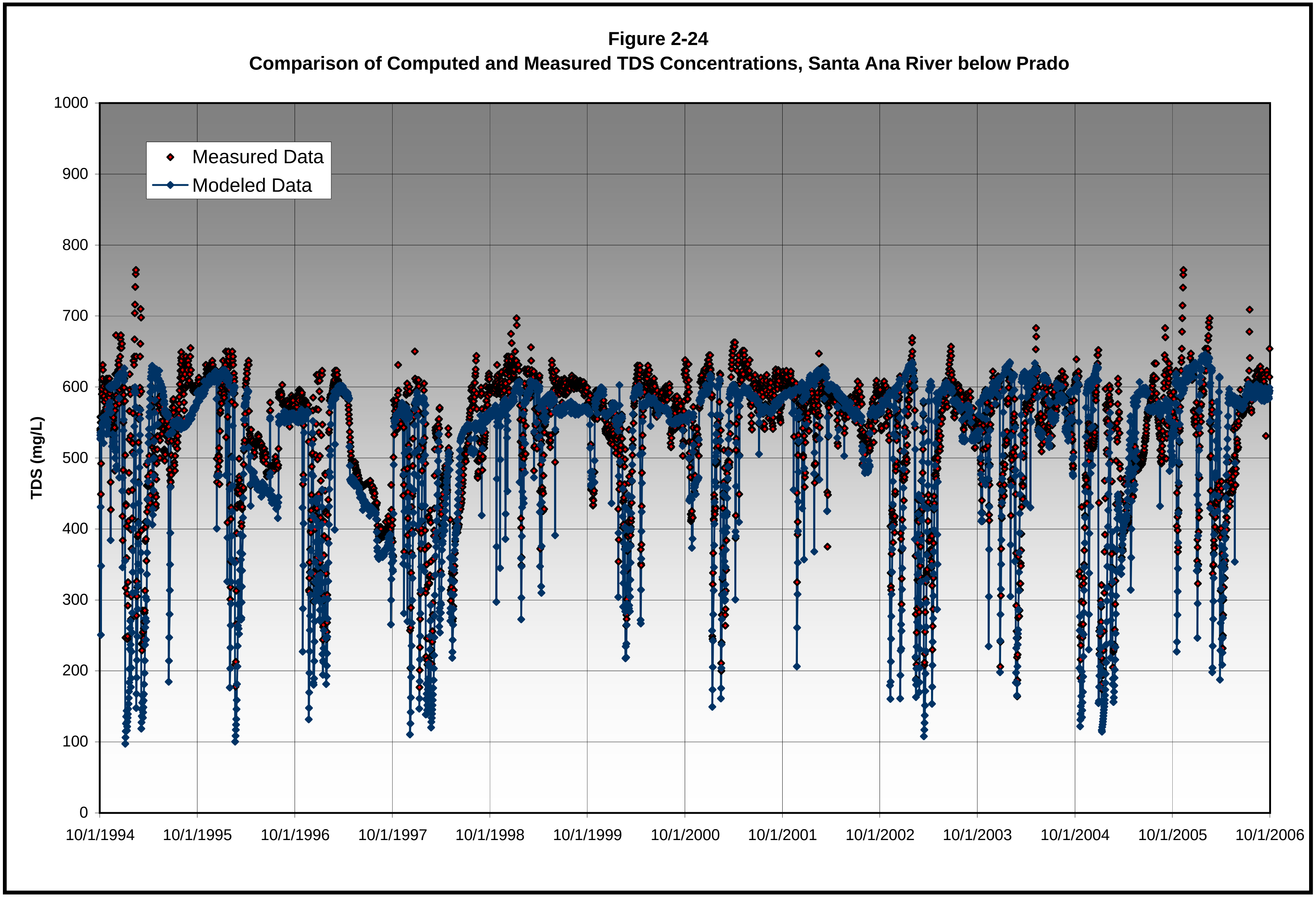
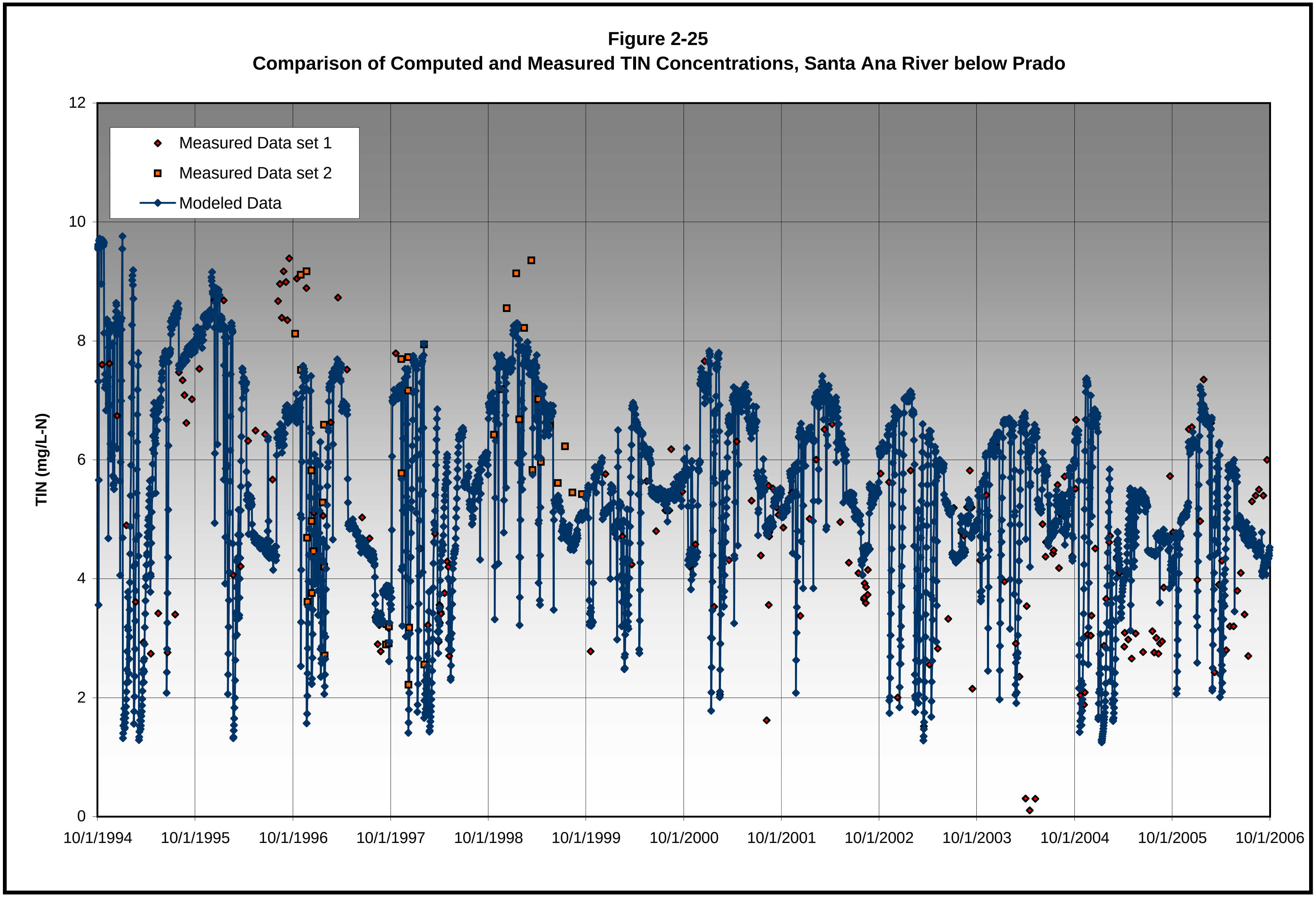


Figure 2-24
Comparison of Computed and Measured TDS Concentrations, Santa Ana River below Prado
Measured Data
Modeled Data
TDS (mg/L)
1000
900
800
700
600
500
400
300
200
100
0
10/1/1994
10/1/1995
10/1/1996
10/1/1997
10/1/1998
10/1/1999
10/1/2000
10/1/2001
10/1/2002
10/1/2003
10/1/2004
10/1/2005
10/1/2006



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Section 3 – Comparison of Updated and Previous Models

The updated WLAM was used to re-simulate the 2003 scenarios that were included in the 2004 Basin Plan Amendment. Upon completion, the results of the updated WLAM simulations were compared to the 2003 results. The purpose of this comparison was to determine if there were any significant differences between the 2003 WLAM and the 2008 WLAM as a result of model recalibration. The results of this comparison are discussed below.

3.1 2010A and 2010B Wasteload Allocation Simulations

The objective of the wasteload allocation simulations in 2003 was to determine if the then current wasteload allocation developed for the 1995 Basin Plan was still applicable for the ambient TDS and TIN concentrations and the proposed TDS and TIN objectives. This was done using the calibrated WLAM model to estimate the values of the 1995 Basin Plan metrics and other management metrics for future estimates of recycled water discharge to surface water. The metrics were evaluated assuming a constant recycled water discharge condition over a 50-year period (1949/50 to 1998/99). These simulations allowed for the evaluation of metrics for 2001 and 2010 recycled water discharge alternatives over long-term highly variable hydrologic conditions.

In total, three baseline scenarios or alternatives were evaluated in 2003:

- 2001 Baseline – essentially replicated the year 2001 recycled water discharge conditions and TDS and TIN permit levels.
- 2010 Baseline A (2010A) – consisted of 2010 projected recycled water production and reuse per the 1995 Basin Plan and the TDS and TIN concentrations of then existing permits.
- 2010 Baseline B (2010B) – consisted of 2010 projected recycled water production and reuse as recommended by the POTWs and water supply agencies and the TDS and TIN concentrations of then existing permits.

The simulations presented below are replications of the 2010A and 2010B simulations that were completed in 2003 and documented in *June 2003 Addendum TIN/TDS Study – Phase 2B of the Santa Ana Watershed Wasteload Allocation Investigation* (WEI, 2003), using the newly updated 2008 WLAM. The surface water discharges from POTWs and the associated TDS and TIN concentrations used in this scenario are documented Table 5-5 of the 2004 Basin Plan.

3.2 Comparison of the 2003 and 2008 Models

Tables 3-1 and 3-2 contain the metrics of the previous and current simulation results for TDS and TIN, respectively, over the same 50-year hydrologic period. Note that the evaluation metrics themselves have been modified. The 2003 report (WEI, 2003) metrics consisted of the average 1-year and 5-year volume-weighted average concentration; this is not how compliance is determined. Compliance is determined based on the maximum 1-year and 5-year volume-weighted average concentration. Tables 3-1 and 3-2 list the maximum 1-year and 5-year volume-weighted average TDS and TIN concentrations. Figures 3-1 and 3-2 show the estimated 5-year volume-weighted average TDS and TIN, respectively, over the modeled 50-

year period. From comparing the results of the two models, the following conclusions were reached:

- The updated model estimates a significantly lower TDS concentration (approximately 65mg/L for the 2010A 5-year average) and TIN concentration (approximately 1.3 mg/L-N for the 2010A 5-year average) for Reaches 2, 3, and 4 of the San Timoteo Creek.
- The updated model estimates an increased TDS concentration (approximately 73 mg/L for the 2010A 5-year average) and TIN concentration (approximately 1.2 mg/L-N for the 2010A 5-year average) for portions of Santa Ana River Reach 4 overlying the Riverside A management zone.
- The updated model estimates an increased TDS (approximately 26 mg/L for the 2010A 5-year average) for portions of Santa Ana River Reach 3 overlying the Chino South management zone.
- There is a little difference between model results for the August only TDS concentration (approximately 10 mg/L for the 2010A) and TIN concentration (approximately 0.1 mg/L-N for the 2010A) below Prado Dam.
- There is a negligible difference between the models results for the estimated maximum 5-year volume-weighted average TDS concentration (approximately 0 mg/L for the 2010A) and TIN concentration (approximately 0.1 mg/L-N for the 2010A) below Prado Dam. The maximum 5-year volume-weighted average TDS and TIN concentrations occur during dry periods. During wet periods, there is not a negligible difference between the two models. This difference is approximately 96 mg/L TDS for 2010A in 1982 and approximately 0.6 mg/L-N TIN for 2010A in 1969.

The significant differences in modeled water quality within the San Timoteo and Beaumont area can be explained by a better understanding of the conceptual hydrologic model and new data sources in the region. Since 2001, surface water and groundwater models were developed for the Beaumont Basin. This work provided an analysis and estimation of surface water runoff and recharge in the area. The runoff and recharge estimates of this modeling work were reviewed and incorporated in the updated WLAM. A problem in the development of the previous WLAM was the lack of surface water discharge data in San Timoteo Creek in the Beaumont and Yucaipa areas: the only USGS station available for the calibration period was 11057500 (San Timoteo Creek near Loma Linda), and its drainage area is 125 square miles. The YVWD and the San Timoteo Watershed Management Authority initiated monitoring programs along Noble, Coopers, San Timoteo, and Yucaipa Creeks in 2001 and began producing annual reports in 2004. These data have provided the locations of high groundwater where surface water discharge does not percolate in the stream bottom and were incorporated into the calibration, described in Section 2. As a result, the San Timoteo Creek simulation has been greatly improved.

In the previous WLAM, the Seven Oaks Dam was operated for flood control purposes only. Thus, the impacts of senior diversion water rights were not evaluated. In this study, two senior diversion water rights were incorporated: 1) for Bear Valley Municipal Water District and 2) for the SBVWCD (Fuller, 2008). Incorporating these diversions had a significant effect on storm water recharge. By comparison, about 6,000 acre-ft/yr more storm water percolated in Santa Ana River Reach 4 with the previous model than with the updated model. This accounts for the about 45 mg/L increase for the maximum 5-year average TDS concentration and the about 1.2 mg/L-N increase for the maximum 5-year average TIN concentration for Reach 4 of the Santa Ana River.

The updated 2008 model increased percolation rates in Reach 3 of the Santa Ana River during the calibration process. The updated rates result in a change of about 18,000 acre-ft/yr of increased percolation. This increase is consistent with available data and the updated 2007 Chino Basin Watermaster groundwater model (WEI, 2007). With storm water available only periodically during the winter, the water quality of the majority of the percolated is similar to the water quality of point-discharged sources and increases in TDS concentration. The maximum 5-year volume-weighted average TDS concentration increased about 26 mg/L in the 2008 model. And, the maximum 5-year volume-weighted average TIN concentration increased about 0.1 mg/L-N in the 2008 model.

During the calibration of the 2003 model, calibration data were only available for discharge below Prado Dam. The WLAM simulated Prado Dam discharge according to the procedures described in the USACE's Water Manual (USACE, 2000). Actual operations were quite different than described in the Water Manual. This affected model calibration for high runoff periods. Low flow calibration for the 2003 model was very good, as shown in Figure 2-18 of the 2003 model report (WEI, 2003).

During 2008 model calibration, the USACE provided estimated daily discharge into the Prado Basin, which was used as a calibration target. These data were estimated from storage changes behind Prado Dam and outflow through Prado Dam. As shown in Figure 2-16, the 2008 model calibration results show good agreement between measured and modeled discharge below Prado Dam during high and low runoff periods. This is an improvement upon the 2003 model, particularly during high discharge periods.

Table 3-1
Comparison of the Estimated TDS Concentration Metrics Using the 2003 WLAM and 2008 WLAM with the 2010 Baseline A and 2010 Baseline B Planning Alternatives in the 2004 Basin Plan Amendment

Point Where Metric is Evaluated	Underlying Management Zone	TDS Objective (mg/L)	Current Ambient Water Quality (mg/L)	Assimilative Capacity (mg/L)	Compliance Period	Compliance Metric: 2003 Model Evaluation 2010A (mg/L)	2003 Model Evaluation 2010B (mg/L)	2008 Model Evaluation 2010A (mg/L)	2008 Model Evaluation 2010B (mg/L)
						Maximum Value for the Volume-Weighted Average Surface Water [1]			
Santa Ana River below Prado Dam, Reach 2	na	700*	na	na	August	610	646	600	640
						Maximum Value for the Volume-Weighted Average Discharge [1]			
Santa Ana River below Prado Dam, Reach 2	na	650**	na	na	5-Year	537	522	537	520
						Maximum Value for the Volume-Weighted Average Recharge [1]			
Santa Ana River Reach 3 Recharge	Chino South	680	940	na	1-year 5-year	617 584	638 603	629 610	652 629
Santa Ana River Reach 4 Recharge	Riverside A	560	440	120	1-year 5-year	475 401	468 395	519 474	514 469
San Timoteo Creek Reach 2 Recharge	San Timoteo	400	-	na	1-year 5-year	526 509	190 176	532 443	166 131
San Timoteo Creek Reaches 3 and 4 Recharge	San Timoteo	400	-	na	1-year 5-year	524 507	506 472	490 443	440 369
San Timoteo Creek Reaches 3 and 4 Recharge	Beaumont	330	260	70	1-year 5-year	524 507	506 472	490 443	440 369

Notes
1 -- Volume-weighted average recharge values include appropriated adjustments for nitrogen loss during percolation
*-- August Only Surface Water TDS Objective
** -- 5 Five-year moving average Surface Water TDS Objective

Table 3-2

Comparison of the Estimated TIN Concentration Metrics Using the 2003 WLAM and 2008 WLAM with the 2010 Baseline A and 2010 B Baseline Planning Alternatives in the 2004 Basin Plan Amendment

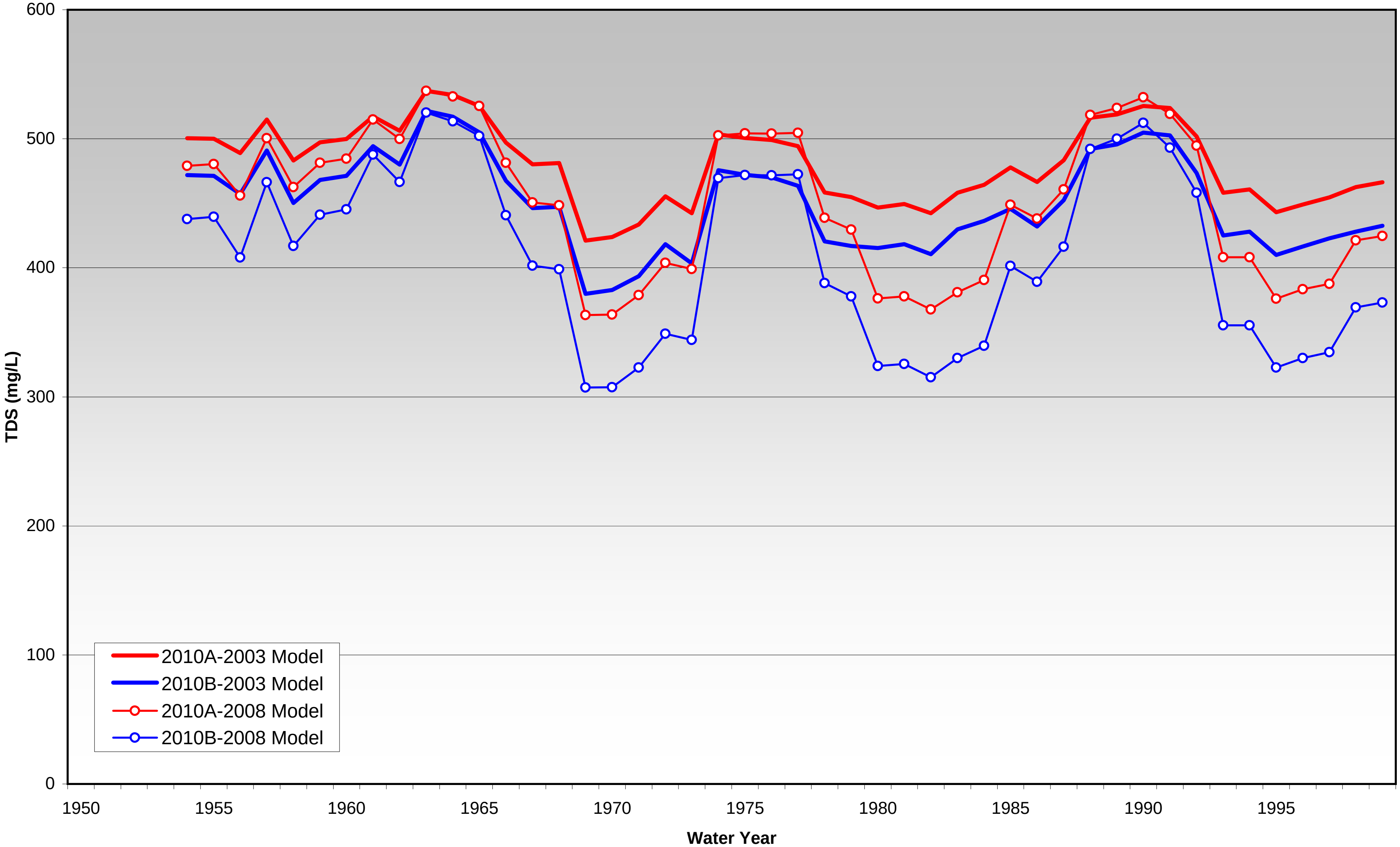
Point Where Metric is Evaluated	Underlying Management Zone	TIN Objective (mg/L)	Current Ambient Water Quality (mg/L)	Assimilative Capacity (mg/L)	Compliance Period	Compliance Metric: 2003 Model Evaluation 2010A (mg/L)	2003 Model Evaluation 2010B (mg/L)	2008 Model Evaluation 2010A (mg/L)	2008 Model Evaluation 2010B (mg/L)
						Maximum Value for the Volume-Weighted Average Surface Water [1]			
Santa Ana River below Prado Dam, Reach 2	na	10.0*	na	na	August	9.6	9.2	9.6	9.3
						Maximum Value for the Volume-Weighted Average Discharge [1]			
Santa Ana River below Prado Dam, Reach 2	na	na	na	na	5-Year	8.0	7.1	8.1	7.2
						Maximum Value for the Volume-Weighted Average Recharge [1]			
Santa Ana River Reach 3 Recharge	Chino South	4.2	25.7	na	1-year 5-year	4.6 4.4	4.6 4.3	4.6 4.5	4.6 4.5
Santa Ana River Reach 4 Recharge	Riverside A	6.2	4.9	1.3	1-year 5-year	6.4 5.2	6.3 5.2	7.1 6.4	7.1 6.4
San Timoteo Creek Reach 2 Recharge	San Timoteo	5.0	-	na	1-year 5-year	7.2 6.9	1.1 1.1	6.9 5.7	1.2 0.9
San Timoteo Creek Reaches 3 and 4 Recharge	San Timoteo	5.0	-	na	1-year 5-year	7.1 6.9	6.9 6.3	6.2 5.5	5.4 4.4
San Timoteo Creek Reaches 3 and 4 Recharge	Beaumont	5.0	1.6	3.4	1-year 5-year	7.1 6.9	6.9 6.3	6.2 5.5	5.4 4.4

Notes

1 -- Volume-weighted average recharge values include appropriated adjustments for nitrogen loss during percolation

*-- Surface Water TIN Objective

Figure 3-1
Estimated 5-Year Volume-Weighted TDS Concentration for the Santa Ana River below Prado Dam for the 2010A and 2010B Scenarios - Estimated with the 2003 and 2008 Models



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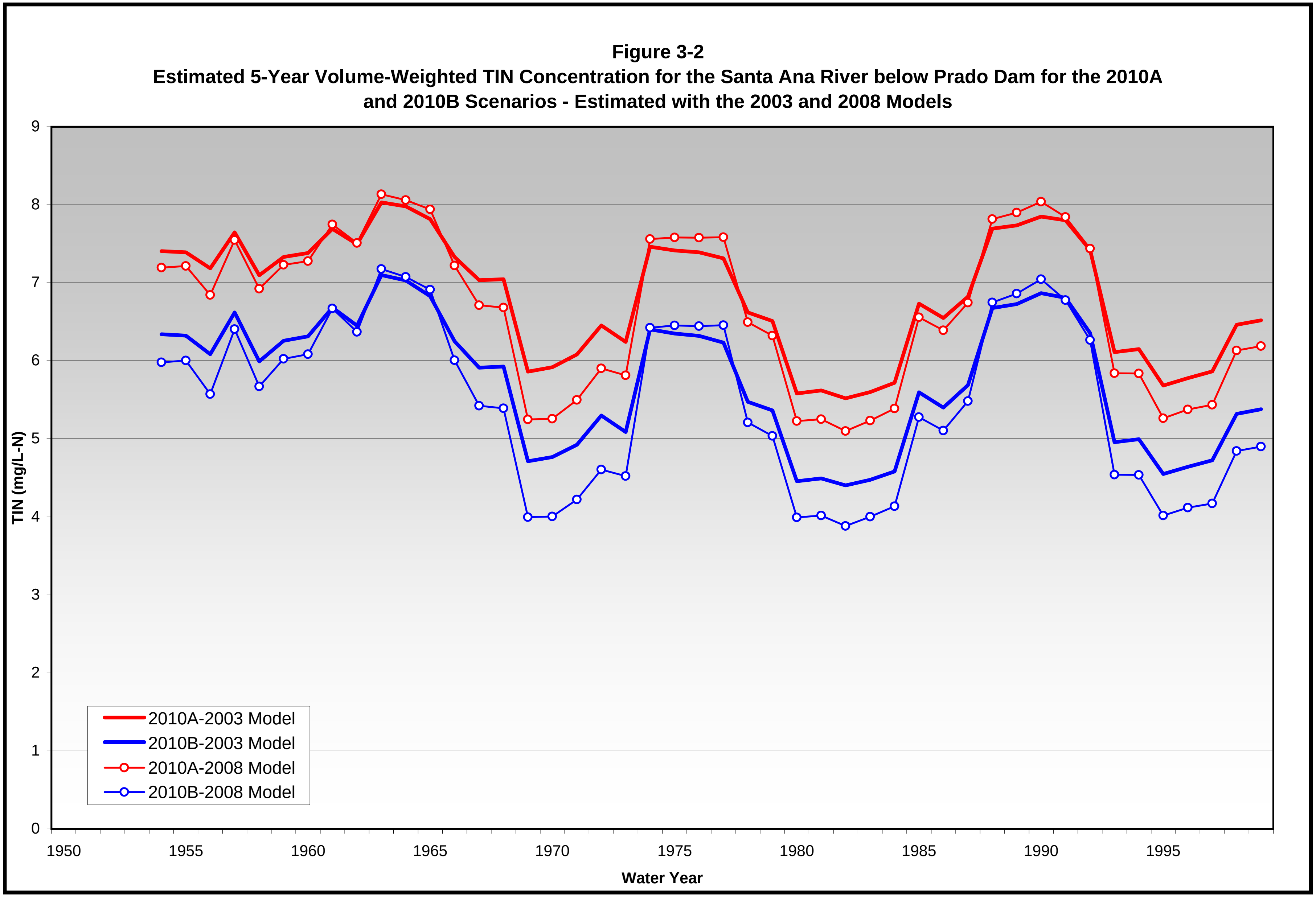


Figure 3-2
Estimated 5-Year Volume-Weighted TIN Concentration for the Santa Ana River below Prado Dam for the 2010A and 2010B Scenarios - Estimated with the 2003 and 2008 Models
TIN (mg/L-N)
0
1
2
3
4
5
6
7
8
9
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
Water Year
2010A-2003 Model
2010B-2003 Model
2010A-2008 Model
2010B-2008 Model

4.1 Planning Simulations

Using the updated WLAM, WEI evaluated varying wasteload discharge scenarios to determine how projected discharges to the Santa Ana River will affect water quality. Based on feedback from the June 2, 2008 Basin Monitoring Task Force meeting, four wasteload allocation scenarios were identified. On November 19, 2008, two additional scenarios were identified for simulation. The first scenarios, 2010A and 2010B, collectively referred to as Scenario 1, are described in Section 3 of this report and are essentially the WLA in the 2004 Basin Plan. The five additional scenarios and their simulation results are discussed below.

4.1.1 Scenario 2 – 2010 and 2020 Worst Case Discharge with the Seven Oaks Diversion

In this scenario, future recycled water reuse plans from POTWs with permit TDS concentration limits less than the TDS concentration objective for the Orange County management zone (580 mg/L) are assumed to be fully implemented, and the recycled water reuse for POTWs that discharge recycled water with TDS concentration limits greater than the Orange County management zone TDS concentration objective are assumed to remain at 2007 levels. The changes in Santa Ana River discharge at Seven Oaks Dam, caused by the proposed diversion of low TDS concentration storm water by the SBVMWD and the Western Municipal Water District (WMWD), is also assumed to occur. This scenario will likely result in the highest TDS concentrations in all reaches of the River where discharge occurs. The formulas for calculating the discharge of each POTW are provided below.

If a POTW permit limit for TDS concentration is <580 mg/L:

Then the POTW Discharge to the Santa Ana River = Projected Plant Discharge – Projected Recycled Water Reuse Amount

If a POTW permit limit for TDS concentration is >580 mg/L:

Then the POTW Discharge to Santa Ana River = Projected Plant Discharge or Permitted Discharge, whichever is greater – 2007 Recycled Water Reuse Amount

Table 4-1 lists the POTW wastewater facility planned design capacities, the permit limits for TDS and TIN concentrations, the 2004 Basin Plan wasteload allocation discharge, the projected discharge for Scenario 2, and the projected recycled water reuse for Scenario 2.

4.1.2 Scenario 3 – 2010 and 2020 Worst Case Discharge without the Seven Oaks Diversion

This simulation is identical to Scenario 2 with the exception that the SBVMWD and WMWD diversion at Seven Oaks Dam is assumed not to occur. The SBVMWD and WMWD diversion is associated with the SBVMWD and WMWD Santa Ana River Water Right Application. The water right application is anticipated to be approved in 2009. This simulation was conducted in case a Basin Plan Amendment is prepared prior to the approval of the SBVMWD and WMWD diversion permit.

Table 4-2 lists the POTW wastewater facility design capacities, the permit limits for TDS and TIN concentrations, the 2004 Basin Plan wasteload allocation discharge, the projected discharge for Scenario 3, and the projected recycled water reuse for Scenario 3.

4.1.3 Scenario 4 – 2010 and 2020 Worst Case Mass Discharge

This simulation assumes that all POTWs discharge at plant capacity with no recycled water reuse. The changes in Santa Ana River discharge at Seven Oaks Dam, caused by the proposed diversion of low TDS concentration storm water by SBVMWD and WMWD, is assumed to occur.

Table 4-3 lists the POTW wastewater facility design capacities, the permit limits for TDS and TIN concentrations, the 2004 Basin Plan wasteload allocation discharge, the projected discharge for Scenario 4, and the projected recycled water reuse for Scenario 4.

4.1.4 Scenario 5 – 2010 and 2020 Planned Discharge

This simulation assumes that all POTWs discharge at their planned discharge rates in 2010 and 2020. The diversion of low TDS concentration storm water by SBVMWD and WMWD is assumed to occur.

Table 4-4 lists the POTW wastewater facility design capacities, the permit limits for TDS and TIN concentrations, the 2004 Basin Plan wasteload allocation discharge, the projected discharge for Scenario 5, and the projected recycled water reuse for Scenario 5.

4.1.5 Scenario 6 – 2010 and 2020 Planned Discharge with Additional Discharge Point and Increase TDS Permit Condition

This scenario is the same as Scenario 5 with two differences. The first is the addition of discharge from March Wastewater Reclamation Facility into Santa Ana River in Reach 3. The discharge will be to the Jefferson Street Storm Drain in the City of Riverside. This storm drain discharges to the Santa Ana River via Hole Lake and is assumed to occur from November through April of each year. The second difference is an increase in the TDS concentration of the EMWD's recycled water discharge to Temescal Wash near Nichols Road. The EMWD's existing TDS concentration limit is 650 mg/L. In this scenario, the EMWD's TDS concentration limit was increased to 700 mg/L.

Table 4-5 lists the POTW wastewater facility design capacities, the permit limits for TDS and TIN concentrations, the 2004 Basin Plan wasteload allocation discharge, the projected discharge for Scenario 6, and the projected recycled water reuse for Scenario 6.

4.2 Planning Assumptions

4.2.1 Hydrology

A daily 50-year precipitation record for the period of 1949/50 to 1998/99 was used for the planning simulations. This period allowed for the evaluation of metrics for recycled water discharge alternatives over long-term highly variable hydrologic conditions. A total of 43 precipitation stations were used to estimate daily precipitation across the model domain. Precipitation varies by elevation and location. Two gages with complete 50-year records but differing precipitation statistics include the Ontario Fire Station gage (Station 1026) and the San Bernardino City – Devil gage (Station 2071). Over the 50-year period, the Ontario Fire Station gage has a mean annual total precipitation of 15.9 inches, and the San Bernardino City – Devil gage has a mean annual total precipitation of 23.7 inches.

4.2.2 Planning Land Use

Land use data within the watershed was developed for the 50-year planning period based on available SCAG data for 2001 and 2005.

4.2.3 Non-Tributary Discharges

No discharges of State Water Project water through OC-59 or groundwater from the San Bernardino area were assumed to occur in these simulations.

4.2.4 Seven Oaks Reservoir Operations

The SBVWMD and the WMWD have filed a water rights application with the State Water Resources Control Board (SWRCB) to divert up to 200,000 acre-ft of water per year from the Santa Ana River (SBVWMD & WMWD, 2004). There are existing senior water rights to divert water from the Seven Oaks Dam (Fuller, 2008):

1. Diversions by senior water rights claimants, which range between historical diversions and up to 88 cfs
2. Diversion by the SBVWCD of up to 10,800 acre-ft per year
3. Releases of surface water from Seven Oaks Dam of up to 1,000 cfs for 2 days when water is available to accommodate habitat restoration
4. Operation of Seven Oaks Dam for flood control or seasonal storage

WEI developed a computer model to simulate operations at Seven Oaks Dam with and without the SBVMWD and WMWD applied diversion rights of up to 1,500 cfs. The Seven Oaks Dam simulation results are used as a boundary inflow for the WLAM.

4.2.5 Prado Wetlands Operations

The nitrogen loss provided by the Prado wetlands was set to zero because the wetlands were built and funded by OCWD to provide treatment of Santa Ana River discharge above that provided by the POTWs that discharge to the River. The TDS increase caused by the Prado wetlands was included in the WLAM simulation by treating the Prado wetlands as a surface water reservoir.

4.2.6 Hidden Valley Wetlands Operations

The Hidden Valley Wetlands were used in the planning simulations for the City of Riverside's discharge of up to 10 mgd (Johannesson, 2008) for Scenarios 2, 3, 4, 5 and 6. TIN removal was assumed to be 5.3 mg/L-N for discharge routed through the wetlands. A TDS increase 7.6 mg/L was also assumed for water passing through the wetlands. The nitrogen decrease and TDS increase are the average increase and decrease in concentrations based on the City of Riverside's daily operational data, gathered at the wetlands from 1994 through 1999. These are the same assumptions applied in the 2003 WLAM.

4.2.7 Lake Elsinore Discharge

Historical outflow from Lake Elsinore could not be used in the WLAM planning simulations due to planned operational changes. Planned operations at Lake Elsinore will utilize a reduced storage capacity, causing more frequent discharge (outflow) from the Lake.

The EVMWD plans to discharge recycled water to the Lake, thereby operating the Lake at 1,240 feet mean sea level. For the WLAM simulations, Lake Elsinore discharges were estimated based on the HEC-5 simulations developed by Riverside County, which reflect planned operations.

WEI obtained the HEC-5 model output files and built a constantly stirred reactor model for TDS using the inflow, outflow, and storage data. A long-term volume-weighted average TDS concentration of 543 mg/L was estimated based on following assumptions:

- The initial conditions for TDS and TIN concentrations are 1,100 mg/L and 1 mg/L-N, respectively (Black & Veatch, 1994).
- Storm water inflow TDS and TIN concentrations of 180 mg/L and 1 mg/L-N, respectively (WEI, 2001).
- EVMWD wastewater discharge to the Lake equals their permit TDS limit of 700 mg/L.

Based on the County of Riverside HEC-5 model, there were five years (six instances) of significant discharge from Lake Elsinore. Table 4-6 lists the periods of discharge, the average discharge, the total discharge, and the calculated TDS concentration. The discharge periods listed in Table 4-6 were used as model inputs for the WLAM. These discharge periods used the volume-weighted average TDS concentration (543 mg/L) and a TIN concentration of 1 mg/L-N. The TIN concentration is based on the normal range of TIN for Lake Elsinore, 0.5 mg/L-N to 1.5 mg/L-N, and the Lake ambient TIN concentration limit of 1.5 mg/L-N (Black & Veatch, 1994). When outflow occurs after major runoff events, the storm water inflow significantly reduces the TIN prior to spilling.

4.2.8 Nitrogen Loss Rate in Streambed Recharge

For streambed recharge, a 25 percent reduction in TIN concentrations was assumed to occur, per the direction of the Task Force, in all reaches where percolation occurs except for the Chino South management zone where a 50 percent reduction was assumed. This assumption is consistent with the 2004 Basin Plan.

4.2.9 Chino Basin Facilities Improvement Program

The Chino Basin Facilities Improvements Program (CBFIP) is a joint project of the Chino Basin Watermaster, the CBWCD, the IEUA, and the SBCFCD. The objective of the CBFIP is to increase the recharge of storm, imported, and recycled water to the Chino Groundwater Basin. Under the CBFIP, improvements associated with the following basins were made: Victoria, San Sevaine, Banana, Hickory, Jurupa, RP3, Declez, Lower Day, 7th and 8th Street, Turner, College Heights, Upland, and Brooks. CBFIP construction was completed in December 2005. WEI obtained detailed information on the projects and incorporated this information into the WLAM.

4.2.10 San Timoteo Creek Project

The USACE and the SBCFCD constructed 18 debris basins along San Timoteo Creek between California Street and Cypress Way. Construction was completed in 2006. WEI obtained detailed information on this project and incorporated it into the WLAM.

4.3 Metrics Used to Evaluate the Wasteload Allocation Scenarios

In the 2003 WLAM evaluation, six metrics were developed based on surface water stream reaches and two locations along the Santa Ana River. For this investigation, the presentation of the metrics was modified slightly to provide better management information related to groundwater recharge from the surface water system. The modified presentation is based on groundwater management zone boundaries rather than surface water reaches. The evaluation statistics also changed from the average of the 1-year and 5-year volume-weighted averages to the maximum 1-year and 5-year volume-weighted averages. This new presentation is shown both in the tables and the improved time history charts.

4.4 Results of the Wasteload Allocation Simulations

Tables 4-7 and 4-8 summarize the estimated TDS and TIN concentration metrics for each point where metrics were evaluated for the 2001 Baseline and show the maximum volume-weighted TDS and TIN concentrations of surface water recharge for each groundwater management zone.

Appendices B through K contain detailed tabular and graphical results of the 2010 and 2020 conditions for each scenario. Moreover, the tables and figures in these appendices show the 50-year time series of discharge and associated volume-weighted TDS and TIN concentrations within each management zone and metric location. The contents of each appendix are listed below:

- Appendix B – Scenario 2, Year 2010 Simulation Results
- Appendix C – Scenario 2, Year 2020 Simulation Results
- Appendix D – Scenario 3, Year 2010 Simulation Results
- Appendix E – Scenario 3, Year 2020 Simulation Results
- Appendix F – Scenario 4, Year 2010 Simulation Results
- Appendix G – Scenario 4, Year 2020 Simulation Results
- Appendix H – Scenario 5, Year 2010 Simulation Results
- Appendix I – Scenario 5, Year 2020 Simulation Results
- Appendix J – Scenario 6, Year 2010 Simulation Results
- Appendix K – Scenario 6, Year 2020 Simulation Results

The specific results for each metric are provided below for each scenario. Unless otherwise noted, the volume-weighted average discussed is the maximum 5-year volume-weighted average over the 50-year simulation period. Tables 4-7 and 4-8 validate the current wasteload allocation for reaches and management zones where the maximum 1-yr and 5-yr volume-weighted average recharge does not exceed an objective. The occurrence of a projected 1-yr and/or 5-yr volume-weighted average recharge exceeding an objective in any one scenario does not mean that the current wasteload allocation is deficient for that scenario. The appendices contain projected time series of recharge and 1-yr and 5-yr metrics for each scenario. In some cases, the maximum 1-yr and 5-yr metrics exceed an objective for a few years in the 50-year simulation period (e.g. TDS in the Bunker Hill B management zone); in other cases, the exceedances are chronic (e.g. TIN in the Chino South management zone). In these latter cases, the Regional Board must use its discretion in evaluating the results presented herein to determine the need for a change in the wasteload allocation or to pursue some other regulatory approach.

4.4.1 Beaumont Management Zone

Portions of San Timoteo Creek and Coopers Creek overly the Beaumont management zone. The City of Beaumont discharges into Coopers Creek within the Beaumont management zone, and due to high groundwater, streambed recharge does not occur. The surface water discharge passes through the Beaumont management zone and into the San Timoteo management zone: no recycled water recharges within the Beaumont management zone.

Tables 4-7 and 4-8 summarize the results of each modeling scenario for the Beaumont management zone. The water quality objectives for the Beaumont management zone are 330 mg/L for TDS and 5 mg/L-N for TIN. The maximum 1-year and 5-year volume-weighted streambed recharge concentrations for TDS and TIN were the same for all scenarios in the Beaumont management zone. As listed in Table 4-7 and 4-8, the 1-year and 5-year volume-weighted TDS concentrations are 166 mg/L and 124 mg/L for 2010 and 2020. The 1-year and 5-year volume-weighted TIN concentrations are 1.2 mg/L-N and 1.0 mg/L-N for 2010 and

2020. The 2004 Basin Plan water quality objectives for the Beaumont management zone were not exceeded; the existing wasteload allocation is acceptable for all scenarios.

4.4.2 San Timoteo Management Zone

The majority of the San Timoteo Creek system (Reach 2, Reach 3, and most of Reach 4) overlies the San Timoteo management zone, as shown in Figure 1-2. The San Timoteo management zone extends from the confluence of Coopers Creek and San Timoteo Creek to the downstream end of Reach 2 of San Timoteo Creek. Streambed recharge within this management zone consists of storm water and recycled water from the City of Beaumont and the YVWD. The City of Beaumont discharges recycled water to Coopers Creek, and the YVWD discharges recycled water to San Timoteo Creek at the upstream end of Reach 3. No portion of San Timoteo Creek is lined within the San Timoteo management zone.

Tables 4-7 and 4-8 summarize the results of each modeling scenario for the San Timoteo management zone. A detailed annual summary of model results for each scenario has been included in Appendices A through K.

The maximum 1-year and 5-year volume-weighted streambed recharge concentration for TDS range between 436 mg/L and 465 mg/L for the 1-year compliance period and 388 mg/L and 457 mg/l for the 5-year compliance period. The maximum 1-year and 5-year volume-weighted TIN concentrations range between 3.7 mg/L-N and 3.9 mg/L-N for the 1-year compliance period and 3.3 mg/L-N and 3.7 mg/l-N for the 5-year compliance period. The water quality objectives for the San Timoteo management zone are 400 mg/L for TDS and 5 mg/L-N for TIN. In Scenarios 2, 3, 4, 5, and 6, the 5-year volume-weighted average TDS concentration exceeds the 2004 Basin Plan water quality objective. Currently, it is unknown whether there is assimilative capacity in this management zone due to insufficiencies in available data for computing current ambient TDS and TIN concentrations (WEI, 2008).

A review of the projected time series of recharge and the 1-yr TDS metrics for each scenario (illustrated graphically in the appendices) shows that the number of annual occurrences where the volume-weighed TDS concentration in recharge exceeds the objective is 26 times out of 50 (slightly greater than 50 percent) for all scenarios except Scenario 4, in which the number of exceedances is 34 out of 50. For 2020, the number of exceedances declines to 6 out of 50 for all scenarios except Scenario 4, in which the number of exceedances remains 34.

4.4.3 Bunker Hill B Management Zone

Reach 5 of the Santa Ana River and Reach 1 of San Timoteo Creek overlay the Bunker Hill B management zone, as shown on Figure 1-2. There are no POTW discharges to the Santa Ana River in this management zone except discharges from the Cities of Redlands and San Bernardino when the storm water discharge in the Santa Ana River is large and they are then permitted to divert recycled water directly to the Santa Ana River. For this investigation, these recycled water discharges were assumed to not occur. The water quality differences between the scenarios are dictated by changes in upstream discharges to San Timoteo Creek and the SBVMWD and WMWD diversion at Seven Oaks Dam on the Santa Ana River. San Timoteo Creek Reach 1 is lined for about 20,000 feet or about 80 percent of its length within the

Bunker Hill B management zone. With the exception of below its confluence with San Timoteo Creek, the Santa Ana River is dry unless there are storms or releases from the Seven Oaks Dam. Discharge in San Timoteo Creek is composed of infrequent storm water discharge, the continuous discharge of recycled water from the YVWD, and occasionally recycled water discharge from the City of Beaumont when storm water is present.

Tables 4-7 and 4-8 summarize the results of each modeling scenario for the Bunker Hill B management zone. A detailed annual summary of model results for each scenario has been included in Appendices A through K.

The maximum 1-year and 5-year volume-weighted streambed recharge concentration for TDS range between 259 mg/L and 452 mg/L for the 1-year compliance period and 211 mg/L and 377 mg/l for the 5-year compliance period. The maximum 1-year and 5-year volume-weighted TIN concentrations range between 2.0 mg/L-N and 3.3 mg/L-N for the 1-year compliance period and 1.6 mg/L-N and 2.8 mg/L-N for the 5-year compliance period. The water quality objectives for the Bunker Hill B management zone are 330 mg/L for TDS and 7.3 mg/L-N for TIN. In Scenarios 2, 3, 4, 5, and 6, the 5-year volume-weighted average TDS concentration exceeds the 2004 Basin Plan water quality objective. There is a 50 mg/L of assimilative capacity for TDS and 1.9 mg/L-N of assimilative capacity for TIN in the Bunker Hill B management zone (WEI, 2008).

A review of the projected time series of recharge and 1-yr TDS metrics for each scenario (illustrated graphically in the appendices) shows that the number of annual occurrences where the volume-weighed TDS concentration in recharge exceeds the TDS objective ranges between 9 and 11 out of 50 (about 20 percent of the time) for all scenarios except Scenario 4, in which the number of exceedances is 29 out of 50. For 2020, the number of exceedances declines to zero out of 50 for all scenarios except Scenario 4, in which the number of exceedances is 10 out of 50. Inspection of the projected time series of recharge and the 1-yr and 5-yr TDS metrics clearly shows that the majority of the time the 1-yr and 5-yr TDS metrics are less than the TDS objective and that the volume of recharge is relatively small when the 1-yr and 5-yr TDS metrics exceed the TDS objective. Most of recharge occurs at TDS concentrations that are less than the TDS objective.

4.4.4 Colton Management Zone

The Colton management zone is shown in Figure 1-2. The Colton management zone is downstream of the San Jacinto Fault and upstream of the Rialto-Colton Fault. This area overlies the upper portion of Reach 4 of the Santa Ana River. There are no POTW discharges to the Santa Ana River in this management zone. The water quality differences between the scenarios are dictated by changes in upstream POTW discharges and the SBVMWD and WMWD diversion at Seven Oaks Dam. Outside of storm events or Seven Oaks Dam releases, discharge within the River is typically low to dry.

Tables 4-7 and 4-8 summarize the results of each modeling scenario for the Colton management zone. A detailed annual summary of model results for each scenario has been included in Appendices A through K.

The maximum 1-year and 5-year volume-weighted streambed recharge concentration for TDS is 182 mg/L for the 1-year compliance period (all scenarios are the same) and ranges between 158 mg/L and 173 mg/l for the 5-year compliance period. The maximum 1-year and 5-year volume-weighted average TIN concentration is 1.4 mg/L-N for the 1- year compliance period (all scenarios are the same) and ranges 1.2 mg/L-N and 1.3 mg/L-N for the 5-year compliance period. The water quality objectives for the Colton management zone are 410 mg/L for TDS and 2.7 mg/L-N for TIN. The 2004 Basin Plan water quality objectives are not exceeded under any scenario. The existing wasteload allocation is adequate for the Colton management zone.

4.4.5 Riverside A Management Zone

The Riverside A management zone is shown in Figure 1-2. The Riverside A management zone is downstream of the Rialto-Colton Fault and the Colton management zone and upstream of the Riverside Narrows. This management zone contains the upper portion of Santa Ana River Reach 3 and the majority of Santa Ana River Reach 4. POTW dischargers within this management zone include the City of Rialto and the City San Bernardino/City of Colton RIX facility. The Santa Ana River is not lined within this management zone and is typically dry upstream of the Rialto and RIX discharge locations.

Tables 4-7 and 4-8 summarize the results of each modeling scenario for the Riverside A management zone. A detailed annual summary of model results for each scenario has been included in Appendices A through K.

The maximum 1-year and 5-year volume-weighted streambed recharge concentrations for TDS range between 509 mg/L and 522 mg/L for the 1-year compliance period and 470 mg/L and 483 mg/l for the 5-year compliance period. The maximum 1-year and 5-year volume-weighted TIN concentrations range from 7.1 mg/L-N to 7.2 mg/L-N for the 1-year compliance period and 6.5 mg/L-N to 6.6 mg/L-N for the 5-year compliance period. The water quality objectives for the Riverside A management zone are 560 mg/L for TDS and 6.2 mg/L-N for TIN. In Scenarios 2, 3, 4, 5, and 6, the 5-year volume-weighted average TIN concentration exceeds the 2004 Basin Plan water quality objective. There is a 120 mg/L of assimilative capacity for TDS and 1.3 mg/L-N of assimilative capacity for TIN in the Riverside A management zone (WEI, 2008).

A review of the projected time series of recharge and the 1-yr TIN metrics (illustrated graphically in the appendices) for each scenario in 2010 shows that the number of annual occurrences where the volume-weighed TIN concentration in recharge exceeds the TIN objective is 22 times out of 50 (slightly less than half of the time) for all scenarios except Scenario 4, in which the number of exceedances is 26 out of 50. The same is true for 2020. Inspection of the projected time series of recharge and the 1-yr and 5-yr TIN metrics clearly shows that the most of the time the 1-yr and 5-yr TIN metrics are less than the TIN objective and that the volume of recharge is relatively small when the 1-yr and 5-yr TIN metrics exceed the TIN objective. Furthermore, the projected time series of recharge and 1-yr TIN metrics show that most of the recharge occurs at TIN concentrations that are less than the TIN objective.

4.4.6 Chino South Management Zone

The Chino South management zone is located downstream of the Riverside Narrows and upstream of the Prado management zone, as shown in Figure 1-2. This area contains most of Santa Ana River Reach 3. The only POTW discharger within this management zone is the City of Riverside, but recycled water discharge is typically continuous from the Riverside A management zone into Chino South. No portion of the Santa Ana River is lined within the Chino South management zone.

Tables 4-7 and 4-8 summarize the results of each modeling scenario for each groundwater management zone. A detailed annual summary of model results for each scenario has been included in Appendices A through K.

The maximum 1-year and 5-year volume-weighted concentrations for TDS range between 638 mg/L and 678 mg/L for the 1-year compliance period and 618 mg/L and 655 mg/l for the 5-year compliance period. The maximum 1-year and 5-year volume-weighted TIN concentrations range between 4.8 mg/L-N and 5.0 mg/L-N for the 1-year compliance period and 4.6 mg/L-N and 4.8 mg/L-N for the 5-year compliance period. The water quality objectives for the Chino South management zone are 680 mg/L for TDS and 4.2 mg/L-N for TIN. In Scenarios 2, 3, 4, 5 and 6, the 5-year volume-weighted average TIN concentration exceeds the 2004 Basin Plan water quality objective. There is no assimilative capacity for TIN or TDS in the Chino South management zone (WEI, 2008).

A review of the projected time series of recharge and the 1-yr TIN metrics (illustrated graphically in the appendices) for each scenario in 2010 shows that the number of annual occurrences where the volume-weighed TIN concentration of recharge exceeds the TIN objective ranges between 38 to 40 times out of 50 (about 80 percent of the time). For 2020, the range is 39 to 40 times out of 50. Inspection of the projected time series of recharge and 1-yr TIN metrics shows that most of the recharge occurs at TIN concentrations that are greater than the TIN objective.

4.4.7 Santa Ana River below Prado Dam

Reach 2 of the Santa Ana River runs from 17th Street in Santa Ana to Prado Dam. The water quality objective for the Prado management zone is a surface water objective. The compliance point for this surface water objective is measured at the Santa Ana River USGS gaging station located immediately downstream of Prado Dam. Under current and future conditions, the Santa Ana River discharges continuously from Prado Dam to the OCWD diversion works and spreading facilities upstream of 17th Street. No recycled water is discharged directly into Reach 2. Wasteload allocations developed prior to the 2004 Basin Plan Amendment aimed to protect beneficial uses in Orange County by setting TDS and TIN concentration limits for upstream POTW dischargers such that TDS and TIN concentrations of 700 mg/L and 10 mg/L-N, respectively, were met at Prado Dam during the period of lowest discharge (typically August). The Basin Plan contains a five-year, volume-weighted TDS objective for Reach 2 of 650 mg/L that must also be met to protect the beneficial uses of groundwater in Orange County.

Tables 4-7 and 4-8 summarize the results of each modeling scenario for each groundwater management zone. A detailed annual summary of model results for each scenario has been included in Appendices A through K.

The maximum August only volume-weighted streambed recharge concentration is 665 mg/L for TDS and 8.6 mg/L-N for TIN. The maximum 5-year volume-weighted streambed recharge TDS and TIN concentrations below Prado Dam are 567 mg/L and 7.5 mg/L-N, respectively. The August only TDS and TIN water quality objectives for Santa Ana River below Prado Dam are 700 mg/L and 10 mg/L-N, respectively. As stated above, the surface water quality objective for below Prado Dam is a 5-year volume-weighted average of 650 mg/L for TDS (there is no objective for TIN). The 2004 Basin Plan water quality objectives were not exceeded. The existing wasteload allocation is acceptable for all scenarios.

4.5 Summary

Figures 4-1 and 4-2 show the 5-year volume-weighted average concentrations for TDS and TIN for all scenarios in 2010 below Prado Dam. The following conclusions can be drawn from Figures 4-1 and 4-2, Tables 4-7 and 4-8, and the data tables in Appendices B through K:

- Scenario 2 - Worst Case POTW Discharge with the Seven Oaks Diversion: this scenario brackets (has the highest estimated TDS and TIN concentrations) all scenarios except Scenario 4 (the maximum mass discharge).
- Based on estimated TDS and TIN concentrations for the August only, 1-year volume-weighted average, and 5-year volume-weighted average compliance periods, there is little difference between Scenario 2 (Worst Case POTW Discharge with the Seven Oaks Diversion) and Scenario 3 (Worst Case POTW Discharge without the Seven Oaks Diversion).
- Scenario 4 – Maximum Mass Discharge: this scenario results in the highest 1-year and 5-year volume-weighted TDS and TIN concentrations.
- Based on estimated TDS and TIN concentrations for the August only, 1-year volume-weighted average, and 5-year volume-weighted average compliance periods, there is little difference between Scenario 5 (Planned Discharge) and Scenario 6 (Planned Discharge with Additional Discharge Point and Increased TDS Permit Condition).
- The following management zones have TDS or TIN metrics for streambed recharge that exceed Basin Plan objectives and have assimilative capacity:
    - Bunker Hill B management zone – TDS
    - Riverside A management zone – TIN
- In all modeled scenarios, the TIN concentration of Santa Ana River streambed recharge exceeds the Chino South management zone TIN objective. There is no assimilative capacity for TIN in the Chino South management zone.

Table 4-1
Wasteload Allocation Model, Scenario 2 Conditions

Agency	Year	Design Capacity (MGD)	Permit Discharge (MGD)	Permit TDS (mg/L)	Permit TIN (mg/L)	2008 Projected Plant Discharge (MGD)	2008 Projected Recycling (MGD)	2008 Projected Discharge to SAR (MGD)	2007 Actual Recycled Water (MGD)	2010-A or 1995 BP Recycling (MGD)	2010-B or 2001 BP Recycling (MGD)	Scenario 2 - Max TDS with Diversion: TDS (mg/L)	Scenario 2 - Max TDS with Diversion: TIN (mg/L)	Scenario 2 - Max TDS with Diversion: Projected Recycling (MGD)	Scenario 2 - Max TDS with Diversion: Discharge to Santa Ana River (MGD)
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	= (3)	= (4)	= (6) or (8)	(13)
San Timoteo Creek															
City of Beaumont[A]	2010	4.0	4.0	490	6	3.0	0.0	3.0	NA	0.2	1.3	490	6	0.0	3.0
Wastewater Treatment Plant #1	2020	4.0	NA	490	6	6.1	4.3	1.8				490	6	4.3	1.8
Yucaipa Valley Water District[B]	2010	6.7	4.5	540	6	6.6	0.0	6.6	NA	0.0	5.7	540	6	0.0	6.6
H. N. Wochholz WTP	2020	11.0	NA	540	6	8.2	7.3	0.9				540	6	7.3	0.9
Santa Ana River Reach 4															
City of Rialto[C]	2010	11.7	11.7	490	10	9.0	0.4	8.6	NA	0.2	Combined with RIX	490	10	0.4	8.6
Rialto Wastewater Treatment Plant	2020	11.7	NA	490	10	12.0	2.4	9.6				490	10	2.4	9.6
San Bernardino/Colton[D]	2010	40.0	64.0	550	10	30.0	16.0	14.0	NA	0.1	23.5	550	10	16.0	14.0
RIX Facility	2020	40.0	NA	550	10	30.0	16.0	14.0				550	10	16.0	14.0
Santa Ana River Reach 3															
City of Riverside[E]	2010	40.0	40.0	650	13<38 MGD 10>38 MGD	40.0	1.5	38.5	0.2	0.0	0.0	650	12.86	0.2	39.8
Regional Water Quality Control Plant	2020	52.2	NA	650	13<38 MGD 10>38 MGD	50.0	8.9	41.1				650	12.29	0.2	49.8
Chino Creek/Cucamonga Creek/Prado Basin															
Inland Empire Utilities Agency[F]	2010	44.0	44.0	550	8	34.0	13.0	21.0	NA	1.7	42.9	550	8	13.0	21.0
RP1 001 Prado	2020	44.0	NA	550	8	36.0	23.0	13.0				550	8	23.0	13.0
Inland Empire Utilities Agency[F]	2010	11.0	9.7	550	8	10.0	7.0	3.0	NA	NA		550	8	7.0	3.0
Carbon Canyon WRP	2020	12.0	NA	550	8	12.0	9.0	3.0				550	8	9.0	3.0
Inland Empire Utilities Agency[F]	2010	15.0	15.0	550	8	12.0	4.0	8.0	NA	NA		550	8	4.0	8.0
RP-5	2020	24.0	NA	550	8	24.0	10.0	14.0				550	8	10.0	14.0
Inland Empire Utilities Agency[F]	2010	14.0	14.0	550	8	14.0	12.0	2.0	NA	4.5		550	8	12.0	2.0
RP1 002 Cucamonga and RP 4	2020	14.0	NA	550	8	14.0	12.0	2.0				550	8	12.0	2.0
Western Riverside Count[G]	2010	8.0	8.0	625	10	7.2	1.0	6.2	0.0	0.0	0.0	625	10	0.0	8.0
Regional Wastewater Authority WTP	2020	14.0	NA	625	10	11.6	2.0	9.6				625	10	0.0	11.6
Temescal Creek															
City of Corona[H]	2010	11.5	9.0	700	10	9.2	7.7	1.5	0.8	0.9	2.8	700	10	0.8	8.4
Wastewater Treatment Plant #1	2020	14.5	NA	700	10	11.6	10.1	1.5				700	10	0.8	10.8
City of Corona[H]	2010	-	-	-	-	-	-	-	NA			-	-	-	-
Wastewater Treatment Plant #2	2020	-	-	-	-	-	-	-				-	-	-	-
City of Corona[H]	2010	1.0	1.0	700	10	0.5	0.5	0.0	0.3			700	10	0.3	0.7
Wastewater Treatment Plant #3	2020	1.0	NA	700	10	0.8	0.8	0.0				700	10	0.3	0.7
Lee Lake Water District[H]	2010	2.3	1.6	650	13	0.9	0.6	0.2	0.4	0.0	0.0	650	13	0.4	1.2
Wastewater Treatment Plant	2020	2.3	NA	650	13	1.2	0.9	0.4				650	13	0.4	1.2
Elsinore Valley Municipal Water District[I]	2010	8.0	8.0	700	13	7.1	7.1	0.0	1.2	0.0	0.0	700	13	1.2	6.8
Regional WWRP	2020	12.0	NA	700	13	11.1	11.1	0.0				700	13	1.2	9.9
Eastern Municipal Water District[J]	2010	52.1	52.5	650	10	56.2	42.4	62*	29.2	0.0	0.0	650	10	29.2	27.0
(all treatment plants combined)	2020	77.3	NA	650	10	71.2	49.4	72*				650	10	29.2	42.0

References:

A - Joe Reichenberger, Beaumont Cherry Valley Water District

B - Jack Nelson, Yucaipa Valley Water District

C - William Hunt, Consultant to the City of Rialto

D - John Claus, City of San Bernardino

E - Chandra Johannesson, City of Riverside

F - LeAnne Hamilton - Inland Empire Utilities Agency

G - Linda Garcia, Western Municipal Water District

H - SAWPA OWOW Recycled Water Pillar Draft Document

I - Phil Miller - Elsinore Valley Municipal Water District

J - Jayne Joy - Eastern Municipal Water District (rate applied for 6 months (Oct-Mar))

Table 4-2
Wasteload Allocation Model, Scenario 3 Conditions

Agency	Year	Design Capacity (MGD)	Permit Discharge (MGD)	Permit TDS (mg/L)	Permit TIN (mg/L)	2008 Projected Plant Discharge (MGD)	2008 Projected Recycling (MGD)	2008 Projected Discharge to SAR (MGD)	2007 Actual Recycled Water (MGD)	2010-A or 1995 BP Recycling (MGD)	2010-B or 2001 BP Recycling (MGD)	Scenario 3 - Max TDS w/o Diversion TDS (mg/L)	TIN (mg/L)	Projected Recycling (MGD)	Discharge to Santa Ana River (MGD)
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	= (3)	= (4)	= (6) or (8)	(14)
San Timoteo Creek															
City of Beaumont[A]	2010	4.0	4.0	490	6	3.0	0.0	3.0	NA	0.2	1.3	490	6	0.0	3.0
Wastewater Treatment Plant #1	2020	4.0	NA	490	6	6.1	4.3	1.8				490	6	4.3	1.8
Yucaipa Valley Water District[B]	2010	6.7	4.5	540	6	6.6	0.0	6.6	NA	0.0	5.7	540	6	0.0	6.6
H. N. Wochholz WTP	2020	11.0	NA	540	6	8.2	7.3	0.9				540	6	7.3	0.9
Santa Ana River Reach 4															
City of Rialto[C]	2010	11.7	11.7	490	10	9.0	0.4	8.6	NA	0.2	Combined with RIX	490	10	0.4	8.6
Rialto Wastewater Treatment Plant	2020	11.7	NA	490	10	12.0	2.4	9.6				490	10	2.4	9.6
San Bernardino/Colton[D]	2010	40.0	64.0	550	10	30.0	16.0	14.0	NA	0.1	23.5	550	10	16.0	14.0
RIX Facility	2020	40.0	NA	550	10	30.0	16.0	14.0				550	10	16.0	14.0
Santa Ana River Reach 3															
City of Riverside[E]	2010	40.0	40.0	650	13<38 MGD 10>38 MGD	40.0	1.5	38.5	0.2	0.0	0.0	650	12.86	0.2	39.8
Regional Water Quality Control Plant	2020	52.2	NA	650	13<38 MGD 10>38 MGD	50.0	8.9	41.1				650	12.29	0.2	49.8
Chino Creek/Cucamonga Creek/Prado Basin															
Inland Empire Utilities Agency[F]	2010	44.0	44.0	550	8	34.0	13.0	21.0	NA	1.7	42.9	550	8	13.0	21.0
RP1 001 Prado	2020	44.0	NA	550	8	36.0	23.0	13.0				550	8	23.0	13.0
Inland Empire Utilities Agency[F]	2010	11.0	9.7	550	8	10.0	7.0	3.0	NA	NA		550	8	7.0	3.0
Carbon Canyon WRP	2020	12.0	NA	550	8	12.0	9.0	3.0				550	8	9.0	3.0
Inland Empire Utilities Agency[F]	2010	15.0	15.0	550	8	12.0	4.0	8.0	NA	NA		550	8	4.0	8.0
RP-5	2020	24.0	NA	550	8	24.0	10.0	14.0				550	8	10.0	14.0
Inland Empire Utilities Agency[F]	2010	14.0	14.0	550	8	14.0	12.0	2.0	NA	4.5		550	8	12.0	2.0
RP1 002 Cucamonga and RP 4	2020	14.0	NA	550	8	14.0	12.0	2.0				550	8	12.0	2.0
Western Riverside Count[G]	2010	8.0	8.0	625	10	7.2	1.0	6.2	0.0	0.0	0.0	625	10	0.0	8.0
Regional Wastewater Authority WTP	2020	14.0	NA	625	10	11.6	2.0	9.6				625	10	0.0	11.6
Temescal Creek															
City of Corona[H]	2010	11.5	9.0	700	10	9.2	7.7	1.5	0.8	0.9	2.8	700	10	0.8	8.4
Wastewater Treatment Plant #1	2020	14.5	NA	700	10	11.6	10.1	1.5				700	10	0.8	10.8
City of Corona[H]	2010	-	-	-	-	-	-	-	NA			-	-	-	-
Wastewater Treatment Plant #2	2020	-	-	-	-	-	-	-				-	-	-	-
City of Corona[H]	2010	1.0	1.0	700	10	0.5	0.5	0.0	0.3			700	10	0.3	0.7
Wastewater Treatment Plant #3	2020	1.0	NA	700	10	0.8	0.8	0.0				700	10	0.3	0.7
Lee Lake Water District[H]	2010	2.3	1.6	650	13	0.9	0.6	0.2	0.4	0.0	0.0	650	13	0.4	1.2
Wastewater Treatment Plant	2020	2.3	NA	650	13	1.2	0.9	0.4				650	13	0.4	1.2
Elsinore Valley Municipal Water District[I]	2010	8.0	8.0	700	13	7.1	7.1	0.0	1.2	0.0	0.0	700	13	1.2	6.8
Regional WWRP	2020	12.0	NA	700	13	11.1	11.1	0.0				700	13	1.2	9.9
Eastern Municipal Water District[J]	2010	52.1	52.5	650	10	56.2	42.4	62*	29.2	0.0	0.0	650	10	29.2	27.0
(all treatment plants combined)	2020	77.3	NA	650	10	71.2	49.4	72*				650	10	29.2	42.0

References:
A - Joe Reichenberger, Beaumont Cherry Valley Water District
B - Jack Nelson, Yucaipa Valley Water District
C - William Hunt, Consultant to the City of Rialto
D - John Claus, City of San Bernardino
E - Chandra Johannesson, City of Riverside
F - LeAnne Hamilton - Inland Empire Utilities Agency
G - Linda Garcia, Western Municipal Water District
H - SAWPA OWOW Recycled Water Pillar Draft Document
I - Phil Miller - Elsinore Valley Municipal Water District
J - Jayne Joy - Eastern Municipal Water District (rate applied for 6 months (Oct-Mar))

Table 4-3
Wasteload Allocation Model, Scenario 4 Conditions

Agency	Year	Design Capacity (MGD)	Permit Discharge (MGD)	Permit TDS (mg/L)	Permit TIN (mg/L)	2008 Projected Plant Discharge (MGD)	2008 Projected Recycling (MGD)	2008 Projected Discharge to SAR (MGD)	2007 Actual Recycled Water (MGD)	2010-A or 1995 BP Recycling (MGD)	2010-B or 2001 BP Recycling (MGD)	Scenario 4 - Plant Capacity Discharge			
												TDS (mg/L)	TIN (mg/L)	Projected Recycling (MGD)	Discharge to Santa Ana River (MGD)
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	= (3)	= (4)	(15)	= (1)
San Timoteo Creek															
City of Beaumont[A]	2010	4.0	4.0	490	6	3.0	0.0	3.0	NA	0.2	1.3	490	6	0.0	4.0
Wastewater Treatment Plant #1	2020	4.0	NA	490	6	6.1	4.3	1.8				490	6	0.0	4.0
Yucaipa Valley Water District[B]	2010	6.7	4.5	540	6	6.6	0.0	6.6	NA	0.0	5.7	540	6	0.0	6.7
H. N. Wochholz WTP	2020	11.0	NA	540	6	8.2	7.3	0.9				540	6	0.0	11.0
Santa Ana River Reach 4															
City of Rialto[C]	2010	11.7	11.7	490	10	9.0	0.4	8.6	NA	0.2	Combined with RIX	490	10	0.0	11.7
Rialto Wastewater Treatment Plant	2020	11.7	NA	490	10	12.0	2.4	9.6				490	10	0.0	11.7
San Bernardino/Colton[D]	2010	40.0	64.0	550	10	30.0	16.0	14.0	NA	0.1	23.5	550	10	0.0	40.0
RIX Facility	2020	40.0	NA	550	10	30.0	16.0	14.0				550	10	0.0	40.0
Santa Ana River Reach 3															
City of Riverside[E]	2010	40.0	40.0	650	13<38 MGD 10>38 MGD	40.0	1.5	38.5	0.2	0.0	0.0	650	12.85	0.0	40.0
Regional Water Quality Control Plant	2020	52.2	NA	650	13<38 MGD 10>38 MGD	50.0	8.9	41.1				650	12.2	0.0	52.2
Chino Creek/Cucamonga Creek/Prado Basin															
Inland Empire Utilities Agency[F]	2010	44.0	44.0	550	8	34.0	13.0	21.0	NA	1.7	42.9	550	8	0.0	44.0
RP1 001 Prado	2020	44.0	NA	550	8	36.0	23.0	13.0				550	8	0.0	44.0
Inland Empire Utilities Agency[F]	2010	11.0	9.7	550	8	10.0	7.0	3.0	NA	NA		550	8	0.0	11.0
Carbon Canyon WRP	2020	12.0	NA	550	8	12.0	9.0	3.0				550	8	0.0	12.0
Inland Empire Utilities Agency[F]	2010	15.0	15.0	550	8	12.0	4.0	8.0	NA	NA		550	8	0.0	15.0
RP-5	2020	24.0	NA	550	8	24.0	10.0	14.0				550	8	0.0	24.0
Inland Empire Utilities Agency[F]	2010	14.0	14.0	550	8	14.0	12.0	2.0	NA	4.5		550	8	0.0	14.0
RP1 002 Cucamonga and RP 4	2020	14.0	NA	550	8	14.0	12.0	2.0				550	8	0.0	14.0
Western Riverside Count[G]	2010	8.0	8.0	625	10	7.2	1.0	6.2	0.0	0.0	0.0	625	10	0.0	8.0
Regional Wastewater Authority WTP	2020	14.0	NA	625	10	11.6	2.0	9.6				625	10	0.0	14.0
Temescal Creek															
City of Corona[H]	2010	11.5	9.0	700	10	9.2	7.7	1.5	0.8	0.9	2.8	700	10	0.0	11.5
Wastewater Treatment Plant #1	2020	14.5	NA	700	10	11.6	10.1	1.5				700	10	0.0	14.5
City of Corona[H]	2010	-	-	-	-	-	-	-	NA			-	-	-	-
Wastewater Treatment Plant #2	2020	-	-	-	-	-	-	-				-	-	-	-
City of Corona[H]	2010	1.0	1.0	700	10	0.5	0.5	0.0	0.3			700	10	0.0	1.0
Wastewater Treatment Plant #3	2020	1.0	NA	700	10	0.8	0.8	0.0				700	10	0.0	1.0
Lee Lake Water District[H]	2010	2.3	1.6	650	13	0.9	0.6	0.2	0.4	0.0	0.0	650	13	0.0	2.3
Wastewater Treatment Plant	2020	2.3	NA	650	13	1.2	0.9	0.4				650	13	0.0	2.3
Elsinore Valley Municipal Water District[I]	2010	8.0	8.0	700	13	7.1	7.1	0.0	1.2	0.0	0.0	700	13	0.0	8.0
Regional WWRP	2020	12.0	NA	700	13	11.1	11.1	0.0				700	13	0.0	12.0
Eastern Municipal Water District[J]	2010	52.1	52.5	650	10	56.2	42.4	62*	29.2	0.0	0.0	650	10	0.0	52.1
(all treatment plants combined)	2020	77.3	NA	650	10	71.2	49.4	72*				650	10	0.0	77.3

References:

A - Joe Reichenberger, Beaumont Cherry Valley Water District
B - Jack Nelson, Yucaipa Valley Water District
C - William Hunt, Consultant to the City of Rialto
D - John Claus, City of San Bernardino
E - Chandra Johannesson, City of Riverside
F - LeAnne Hamilton - Inland Empire Utilities Agency
G - Linda Garcia, Western Municipal Water District
H - SAWPA OWOW Recycled Water Pillar Draft Document
I - Phil Miller - Elsinore Valley Municipal Water District
J - Jayne Joy - Eastern Municipal Water District (rate applied for 6 months (Oct-Mar))

Table 4-4
Wasteload Allocation Model, Scenario 5 Conditions

Agency	Year	Design Capacity (MGD)	Permit Discharge (MGD)	Permit TDS (mg/L)	Permit TIN (mg/L)	2008 Projected Plant Discharge (MGD)	2008 Projected Recycling (MGD)	2008 Projected Discharge to SAR (MGD)	2007 Actual Recycled Water (MGD)	2010-A or 1995 BP Recycling (MGD)	2010-B or 2001 BP Recycling (MGD)	Scenario 5 - Planned Water Recycling: TDS (mg/L)	Scenario 5 - Planned Water Recycling: TIN (mg/L)	Scenario 5 - Planned Water Recycling: Projected Recycling (MGD)	Scenario 5 - Planned Water Recycling: Discharge to Santa Ana River (MGD)
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(7)	(9)	(10)	= (3)	= (4)	= (6)	= (5) - (6)
San Timoteo Creek															
City of Beaumont[A]	2010	4.0	4.0	490	6	3.0	0.0	3.0	NA	0.2	1.3	490	6	0.0	3.0
Wastewater Treatment Plant #1	2020	4.0	NA	490	6	6.1	4.3	1.8				490	6	4.3	1.8
Yucaipa Valley Water District[B]	2010	6.7	4.5	540	6	6.6	0.0	6.6	NA	0.0	5.7	540	6	0.0	6.6
H. N. Wochholz WTP	2020	11.0	NA	540	6	8.2	7.3	0.9				540	6	7.3	0.9
Santa Ana River Reach 4															
City of Rialto[C]	2010	11.7	11.7	490	10	9.0	0.4	8.6	NA	0.2	Combined with RIX	490	10	0.4	8.6
Rialto Wastewater Treatment Plant	2020	11.7	NA	490	10	12.0	2.4	9.6				490	10	2.4	9.6
San Bernardino/Colton[D]	2010	40.0	64.0	550	10	30.0	16.0	14.0	NA	0.1	23.5	550	10	16.0	14.0
RIX Facility	2020	40.0	NA	550	10	30.0	16.0	14.0				550	10	16.0	14.0
Santa Ana River Reach 3															
City of Riverside[E]	2010	40.0	40.0	650	13<38 MGD 10>38 MGD	40.0	1.5	38.5	0.2	0.0	0.0	650	13<38 MGD 10>38 MGD	1.5	38.5
Regional Water Quality Control Plant	2020	52.2	NA	650	13<38 MGD 10>38 MGD	50.0	8.9	41.1				650	13<38 MGD 10>38 MGD	8.9	41.1
Chino Creek/Cucamonga Creek/Prado Basin															
Inland Empire Utilities Agency[F]	2010	44.0	44.0	550	8	34.0	13.0	21.0	NA	1.7	42.9	550	8	13.0	21.0
RP1 001 Prado	2020	44.0	NA	550	8	36.0	23.0	13.0				550	8	23.0	13.0
Inland Empire Utilities Agency[F]	2010	11.0	9.7	550	8	10.0	7.0	3.0	NA	NA		550	8	7.0	3.0
Carbon Canyon WRP	2020	12.0	NA	550	8	12.0	9.0	3.0				550	8	9.0	3.0
Inland Empire Utilities Agency[F]	2010	15.0	15.0	550	8	12.0	4.0	8.0	NA	NA		550	8	4.0	8.0
RP-5	2020	24.0	NA	550	8	24.0	10.0	14.0				550	8	10.0	14.0
Inland Empire Utilities Agency[F]	2010	14.0	14.0	550	8	14.0	12.0	2.0	NA	4.5		550	8	12.0	2.0
RP1 002 Cucamonga and RP 4	2020	14.0	NA	550	8	14.0	12.0	2.0				550	8	12.0	2.0
Western Riverside Count[G]	2010	8.0	8.0	625	10	7.2	1.0	6.2	0.0	0.0	0.0	625	10	1.0	6.2
Regional Wastewater Authority WTP	2020	14.0	NA	625	10	11.6	2.0	9.6				625	10	2.0	9.6
Temescal Creek															
City of Corona[H]	2010	11.5	9.0	700	10	9.2	7.7	1.5	0.8	0.9	2.8	700	10	7.7	1.5
Wastewater Treatment Plant #1	2020	14.5	NA	700	10	11.6	10.1	1.5				700	10	10.1	1.5
City of Corona[H]	2010	-	-	-	-	-	-	-	NA			-	-	-	0.0
Wastewater Treatment Plant #2	2020	-	-	-	-	-	-	-				-	-	-	0.0
City of Corona[H]	2010	1.0	1.0	700	10	0.5	0.5	0.0	0.3			700	10	0.5	0.0
Wastewater Treatment Plant #3	2020	1.0	NA	700	10	0.8	0.8	0.0				700	10	0.8	0.0
Lee Lake Water District[H]	2010	2.3	1.6	650	13	0.9	0.6	0.2	0.4	0.0	0.0	650	13	0.6	0.2
Wastewater Treatment Plant	2020	2.3	NA	650	13	1.2	0.9	0.4				650	13	0.9	0.4
Elsinore Valley Municipal Water District[I]	2010	8.0	8.0	700	13	7.1	7.1	0.0	1.2	0.0	0.0	700	13	7.1	0.0
Regional WWRP	2020	12.0	NA	700	13	11.1	11.1	0.0				700	13	11.1	0.0
Eastern Municipal Water District[J]	2010	52.1	52.5	650	10	56.2	42.4	62*	29.2	0.0	0.0	650	10	42.4	13.8
(all treatment plants combined)	2020	77.3	NA	650	10	71.2	49.4	72*				650	10	49.4	21.8

References:

A - Joe Reichenberger, Beaumont Cherry Valley Water District
B - Jack Nelson, Yucaipa Valley Water District
C - William Hunt, Consultant to the City of Rialto
D - John Claus, City of San Bernardino
E - Chandra Johannesson, City of Riverside
F - LeAnne Hamilton - Inland Empire Utilities Agency
G - Linda Garcia, Western Municipal Water District
H - SAWPA OWOW Recycled Water Pillar Draft Document
I - Phil Miller - Elsinore Valley Municipal Water District
J - Jayne Joy - Eastern Municipal Water District (rate applied for 6 months (Oct-Mar))

Table 4-5
Wasteload Allocation Model, Scenario 6 Conditions

Agency	Year	Design Capacity (MGD)	Permit Discharge (MGD)	Permit TDS (mg/L)	Permit TIN (mg/L)	2008 Projected Plant Discharge (MGD)	2008 Projected Recycling (MGD)	2008 Projected Discharge to SAR (MGD)	2007 Actual Recycled Water (MGD)	2010-A or 1995 BP Recycling (MGD)	2010-B or 2001 BP Recycling (MGD)	Scenario 6 - Planned Water Recycling: TDS (mg/L)	TIN (mg/L)	Projected Recycling (MGD)	Discharge to Santa Ana River (MGD)
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(7)	(9)	(10)	= (3)	= (4)	= (6)	= (5) - (6)
San Timoteo Creek															
City of Beaumont[A]	2010	4.0	4.0	490	6	3.0	0.0	3.0	NA	0.2	1.3	490	6	0.0	3.0
Wastewater Treatment Plant #1	2020	4.0	NA	490	6	6.1	4.3	1.8				490	6	4.3	1.8
Yucaipa Valley Water District[B]	2010	6.7	4.5	540	6	6.6	0.0	6.6	NA	0.0	5.7	540	6	0.0	6.6
H. N. Wochholz WTP	2020	11.0	NA	540	6	8.2	7.3	0.9				540	6	7.3	0.9
Santa Ana River Reach 4															
City of Rialto[C]	2010	11.7	11.7	490	10	9.0	0.4	8.6	NA	0.2	Combined with RIX	490	10	0.4	8.6
Rialto Wastewater Treatment Plant	2020	11.7	NA	490	10	12.0	2.4	9.6				490	10	2.4	9.6
San Bernardino/Colton[D]	2010	40.0	64.0	550	10	30.0	16.0	14.0	NA	0.1	23.5	550	10	16.0	14.0
RIX Facility	2020	40.0	NA	550	10	30.0	16.0	14.0				550	10	16.0	14.0
Santa Ana River Reach 3															
City of Riverside[E]	2010	40.0	40.0	650	13<38 MGD 10>38 MGD	40.0	1.5	38.5	0.2	0.0	0.0	650	13<38 MGD 10>38 MGD	1.5	38.5
Regional Water Quality Control Plant	2020	52.2	NA	650	13<38 MGD 10>38 MGD	50.0	8.9	41.1				650	13<38 MGD 10>38 MGD	8.9	41.1
Western Municipal Water District[G]	2010	3.0	NA	550	6	3.0	0.7	2.3	NA	NA	NA	550	6	0.7	2.3
March Wastewater Reclamation Facility	2020	5.0	NA	550	6	5.0	0.7	4.3				550	6	0.7	4.3
Chino Creek/Cucamonga Creek/Prado Basin															
Inland Empire Utilities Agency[F]	2010	44.0	44.0	550	8	34.0	13.0	21.0	NA	1.7	42.9	550	8	13.0	21.0
RP1 001 Prado	2020	44.0	NA	550	8	36.0	23.0	13.0				550	8	23.0	13.0
Inland Empire Utilities Agency[F]	2010	11.0	9.7	550	8	10.0	7.0	3.0	NA	NA		550	8	7.0	3.0
Carbon Canyon WRP	2020	12.0	NA	550	8	12.0	9.0	3.0				550	8	9.0	3.0
Inland Empire Utilities Agency[F]	2010	15.0	15.0	550	8	12.0	4.0	8.0	NA	NA		550	8	4.0	8.0
RP-5	2020	24.0	NA	550	8	24.0	10.0	14.0				550	8	10.0	14.0
Inland Empire Utilities Agency[F]	2010	14.0	14.0	550	8	14.0	12.0	2.0	NA	4.5		550	8	12.0	2.0
RP1 002 Cucamonga and RP 4	2020	14.0	NA	550	8	14.0	12.0	2.0				550	8	12.0	2.0
Western Riverside Count[G]	2010	8.0	8.0	625	10	7.2	1.0	6.2	0.0	0.0	0.0	625	10	1.0	6.2
Regional Wastewater Authority WTP	2020	14.0	NA	625	10	11.6	2.0	9.6				625	10	2.0	9.6
Temescal Creek															
City of Corona[H]	2010	11.5	9.0	700	10	9.2	7.7	1.5	0.8	0.9	2.8	700	10	7.7	1.5
Wastewater Treatment Plant #1	2020	14.5	NA	700	10	11.6	10.1	1.5				700	10	10.1	1.5
City of Corona[H]	2010	-	-	-	-	-	-	-	NA			-	-	-	0.0
Wastewater Treatment Plant #2	2020	-	-	-	-	-	-	-				-	-	-	0.0
City of Corona[H]	2010	1.0	1.0	700	10	0.5	0.5	0.0	0.3			700	10	0.5	0.0
Wastewater Treatment Plant #3	2020	1.0	NA	700	10	0.8	0.8	0.0				700	10	0.8	0.0
Lee Lake Water District[H]	2010	2.3	1.6	650	13	0.9	0.6	0.2	0.4	0.0	0.0	650	13	0.6	0.2
Wastewater Treatment Plant	2020	2.3	NA	650	13	1.2	0.9	0.4				650	13	0.9	0.4
Elsinore Valley Municipal Water District[I]	2010	8.0	8.0	700	13	7.1	7.1	0.0	1.2	0.0	0.0	700	13	7.1	0.0
Regional WWRP	2020	12.0	NA	700	13	11.1	11.1	0.0				700	13	11.1	0.0
Eastern Municipal Water District[J]	2010	52.1	52.5	650	10	56.2	42.4	62*	29.2	0.0	0.0	700	10	42.4	13.8
(all treatment plants combined)	2020	77.3	NA	650	10	71.2	49.4	72*				700	10	49.4	21.8

References:

A - Joe Reichenberger, Beaumont Cherry Valley Water District
B - Jack Nelson, Yucaipa Valley Water District
C - William Hunt, Consultant to the City of Rialto
D - John Claus, City of San Bernardino
E - Chandra Johannesson, City of Riverside
F - LeAnne Hamilton - Inland Empire Utilities Agency
G - Linda Garcia, Western Municipal Water District (rate applied for 5 months (Nov-Mar))
H - SAWPA OWOW Recycled Water Pillar Draft Document
I - Phil Miller - Elsinore Valley Municipal Water District
J - Jayne Joy - Eastern Municipal Water District (rate applied for 6 months (Oct-Mar))

Table 4-6
Modeled Lake Elsinore Discharge and Water Quailty during Periods of Outflow

Period of Overflow[1]		Days	Average Flow (cfs)	Total Flow (acre-ft)	Average TDS (mg/L)
From	To				
3/3/69	5/31/69	90	34	6,107	617
2/3/79	7/8/79	156	22	10,312	624
2/14/80	3/9/80	25	583	28,841	575
3/20/80	8/2/80	136	120	32,402	465
3/4/83	8/31/83	181	93	33,217	674
1/29/93	7/20/93	173	141	48,326	441
				Arithmetic Average	566
				Volume Weighted Average	537

1. Period of overflow estimated with County of Riverside HEC-5 model.

Table 4-7
Comparison of Estimated Metrics for Scenario 2, 3, 4, 5, and 6 Model Runs and Corresponding TDS Objectives for Management Zones Impacted by Streambed Recharge

Reach	Underlying Management Zone	TDS Objective (mg/L)	Current Ambient Water Quality (mg/L)	Assimilative Capacity (mg/L)	Compliance Period	Compliance Metric									
						Scenario 2[1]		Scenario 3[2]		Scenario 4[3]		Scenario 5[4]		Scenario 6[5]	
						2010 (mg/L)	2020 (mg/L)	2010 (mg/L)	2020 (mg/L)	2010 (mg/L)	2020 (mg/L)	2010 (mg/L)	2020 (mg/L)	2010 (mg/L)	2020 (mg/L)
						Maximum Value for the Volume-Weighted Discharge for the Planning Period Hydrology									
Santa Ana River at below Prado Dam, Reach 2	na	700*	na	na	August Only[6]	662	665	662	665	615	615	662	664	662	664
						Maximum Value for the Volume-Weighted Discharge for the Planning Period Hydrology									
Santa Ana River at below Prado Dam, Reach 2	na	650**	na	na	5-Year	541	556	540	556	556	567	532	534	532	535
						Maximum Value for the Volume-Weighted Recharge for the Planning Period Hydrology									
Santa Ana River from Prado Dam to Riverside Narrows, Reach 3	Chino South	680	940	none	1-year 5-year	678 655	672 650	678 655	672 650	638 618	639 619	677 651	672 648	676 650	672 648
Santa Ana River from Riverside Narrows to the Rialto Colton Barrier Projection, Reaches 3 and 4	Riverside A	560	440	120	1-year 5-year	510 471	509 470	510 471	509 470	522 483	522 483	510 471	509 470	510 471	509 470
Santa Ana River from the Rialto Colton Barrier Projection to the San Jacinto Fault, Reach 4	Colton	410	450	none	1-year 5-year	182 158	182 158	182 173	182 172	182 158	182 158	182 158	182 158	182 158	182 158
Santa Ana River from the San Jacinto Fault to Seven Oaks Dam, Reach 5	Bunker Hill B	330	280	50	1-year 5-year	415 331	259 212	415 325	259 211	415 332	452 377	415 331	259 212	415 331	259 212
San Timoteo Creek from San Timoteo Canyon Rd to confluent with Cooper's Creek	San Timoteo	400	-	Unknown[7]	1-year 5-year	457 422	436 388	457 422	436 388	465 437	465 437	457 422	436 388	457 422	436 388
Nobel Creek below Mountain View Channel and San Timoteo Creek in Beaumont Management Zone	Beaumont	330	260	70	1-year 5-year	166 124	166 124	166 124	166 124	166 124	166 124	166 124	166 124	166 124	166 124

Notes

1 -- Scenario 2 represents the Worst Case POTW Discharge with the San Bernardino Valley Municipal Water District (SBVMWD)/Western Municipal Water District (WMWD) Diversion at Seven Oaks Dam.

2 -- Scenario 3 represents the Worst Case Discharge without the SBVMWD/WMWD Diversion at Seven Oaks Dam.

3 -- Scenario 4 represents the Worst Case Mass Discharge.

4 -- Scenario 5 represents planned POTW discharge (2010/2020) with theSBVMWD/WMWD Diversion at Seven Oaks Dam.

5 -- Scenario 6 represents planned POTW discharge (2010/2020) including March Wastewater Reclamation Facility discharged to the Santa Ana River, increased permit TDS limit for Eastern Municipal Water District, and the SBVMWD/WMWD Diversion at Seven Oaks Dam.

6 -- August Only represents the lowest flow period on the Santa Ana at below Prado Dam when the contribution of recycled water discharged to the River is assumed to be the greatest.

7 -- Insufficient data to determine ambient TDS concentration (Wildermuth, 2008).

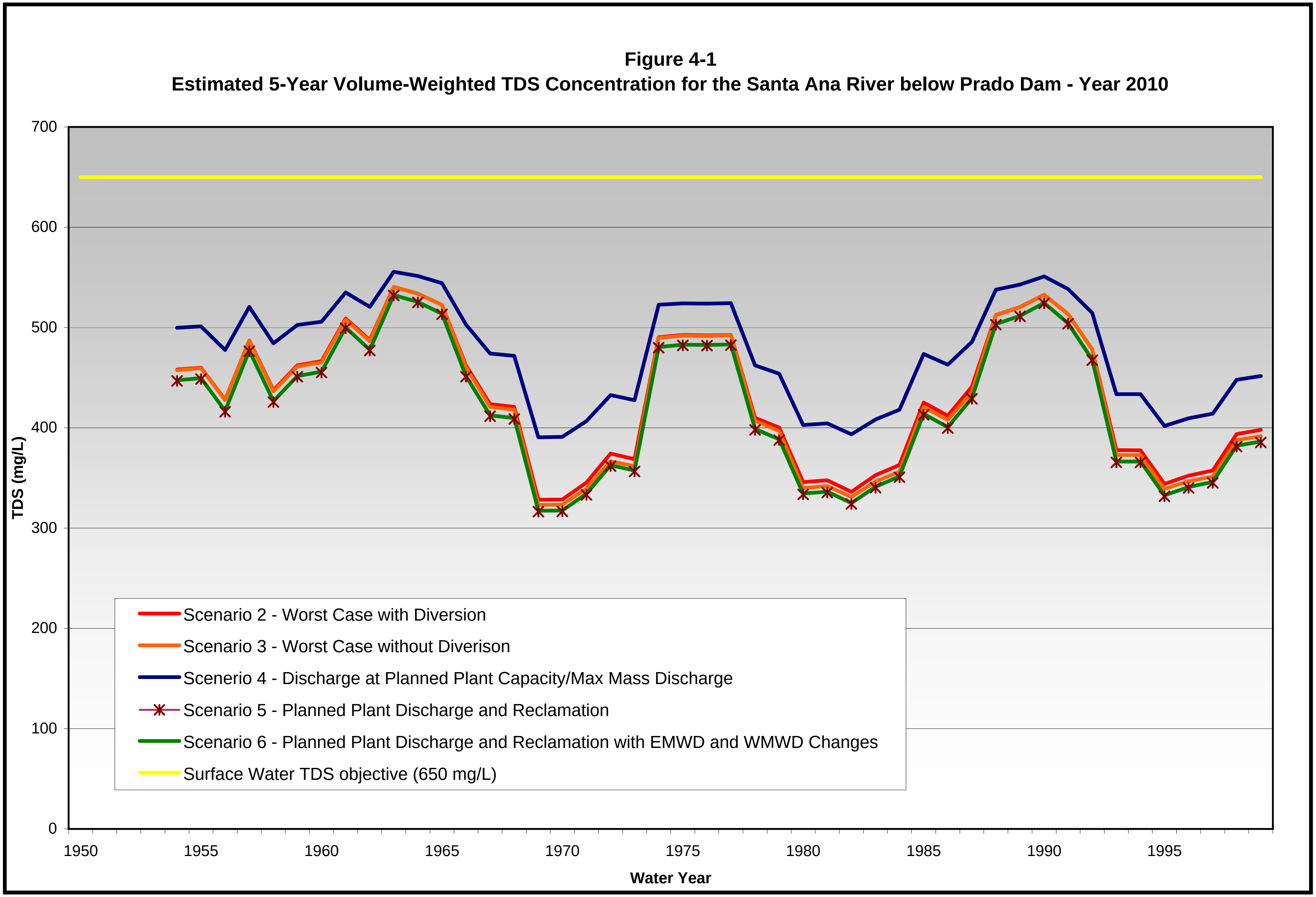
*-- August Only Surface Water TDS Objective

** -- 5 Five-year moving average Surface Water TDS Objective

Table 4-8
Comparison of Estimated Metrics for Scenario 2, 3, 4, 5, and 6 Model Runs and Corresponding TIN Objectives for Management Zones Impacted by Streambed Recharge

Reach	Underlying Management Zone	TIN Objective (mg/L)	Current Ambient Water Quality (mg/L)	Assimilative Capacity (mg/L)	Compliance Period	Compliance Metric									
						Scenario 2[1]		Scenario 3[2]		Scenario 4[3]		Scenario 5[4]		Scenario 6[5]	
						2010 (mg/L)	2020 (mg/L)	2010 (mg/L)	2020 (mg/L)	2010 (mg/L)	2020 (mg/L)	2010 (mg/L)	2020 (mg/L)	2010 (mg/L)	2020 (mg/L)
						Maximum Value for the Volume-Weighted Discharge for the Planning Period Hydrology									
Santa Ana River at below Prado Dam, Reach 2	na	10*	na	na	August Only[6]	8.5	8.6	8.5	8.6	8.3	8.4	8.5	8.5	8.4	8.4
						Maximum Value for the Volume-Weighted Discharge for the Planning Period Hydrology									
Santa Ana River at below Prado Dam, Reach 2	na	na	na	na	5-Year	6.8	7.0	6.8	7.0	7.3	7.5	6.7	6.7	6.7	6.7
						Maximum Value for the Volume-Weighted Recharge for the Planning Period Hydrology									
Santa Ana River from Prado Dam to Riverside Narrows, Reach 3	Chino South	4.2	25.7	none	1-year 5-year	5.0 4.8	4.9 4.8	5.0 4.8	4.9 4.8	4.8 4.6	4.8 4.6	5.0 4.8	4.9 4.8	5.0 4.8	4.9 4.7
Santa Ana River from Riverside Narrows to the Rialto Colton Barrier Projection, Reaches 3 and 4	Riverside A	6.2	4.9	1.3	1-year 5-year	7.1 6.5	7.2 6.5	7.1 6.5	7.2 6.5	7.2 6.6	7.2 6.6	7.1 6.5	7.2 6.5	7.1 6.5	7.2 6.5
Santa Ana River from the Rialto Colton Barrier Projection to the San Jacinto Fault, Reach 4	Colton	2.7	2.9	none	1-year 5-year	1.4 1.2	1.4 1.2	1.4 1.3	1.4 1.3	1.4 1.2	1.4 1.2	1.4 1.2	1.4 1.2	1.4 1.2	1.4 1.2
Santa Ana River from the San Jacinto Fault to Seven Oaks Dam, Reach 5	Bunker Hill B	7.3	5.4	1.9	1-year 5-year	3.1 2.5	2.0 1.6	3.1 2.4	2.0 1.6	3.1 2.5	3.3 2.8	3.1 2.5	2.0 1.6	3.1 2.5	2.0 1.6
San Timoteo Creek from San Timoteo Canyon Rd to confluent with Cooper's Creek	San Timoteo	5	-	Unknown[7]	1-year 5-year	3.9 3.6	3.7 3.3	3.9 3.6	3.7 3.3	3.9 3.7	3.9 3.7	3.9 3.6	3.7 3.3	3.9 3.6	3.7 3.3
Nobel Creek below Mountain View Channel and San Timoteo Creek in Beaumont Management Zone	Beaumont	5	1.6	3.4	1-year 5-year	1.2 1.0	1.2 1.0	1.2 1.0	1.2 1.0	1.2 1.0	1.2 1.0	1.2 1.0	1.2 1.0	1.2 1.0	1.2 1.0

Notes
1 -- Scenario 2 represents the Worst Case POTW Discharge with the San Bernardino Valley Municipal Water District (SBVMWD)/Western Municipal Water District (WMWD) Diversion at Seven Oaks Dam.
2 -- Scenario 3 represents the Worst Case Discharge without the SBVMWD/WMWD Diversion at Seven Oaks Dam.
3 -- Scenario 4 represents the Worst Case Mass Discharge.
4 -- Scenario 5 represents planned POTW discharge (2010/2020) with theSBVMWD/WMWD Diversion at Seven Oaks Dam.
5 -- Scenario 6 represents planned POTW discharge (2010/2020) including March Wastewater Reclamation Facility discharged to the Santa Ana River, increased permit TDS limit for Eastern Municipal Water District, and the SBVMWD/WMWD Diversion at Seven Oaks Dam.
6 -- August Only represents the lowest flow period on the Santa Ana at below Prado Dam when the contribution of recycled water discharged to the River is assumed to be the greatest.
7 -- Insufficient data to determine ambient TIN concentration (Wildermuth, 2008).
*-- Surface Water TIN Objective



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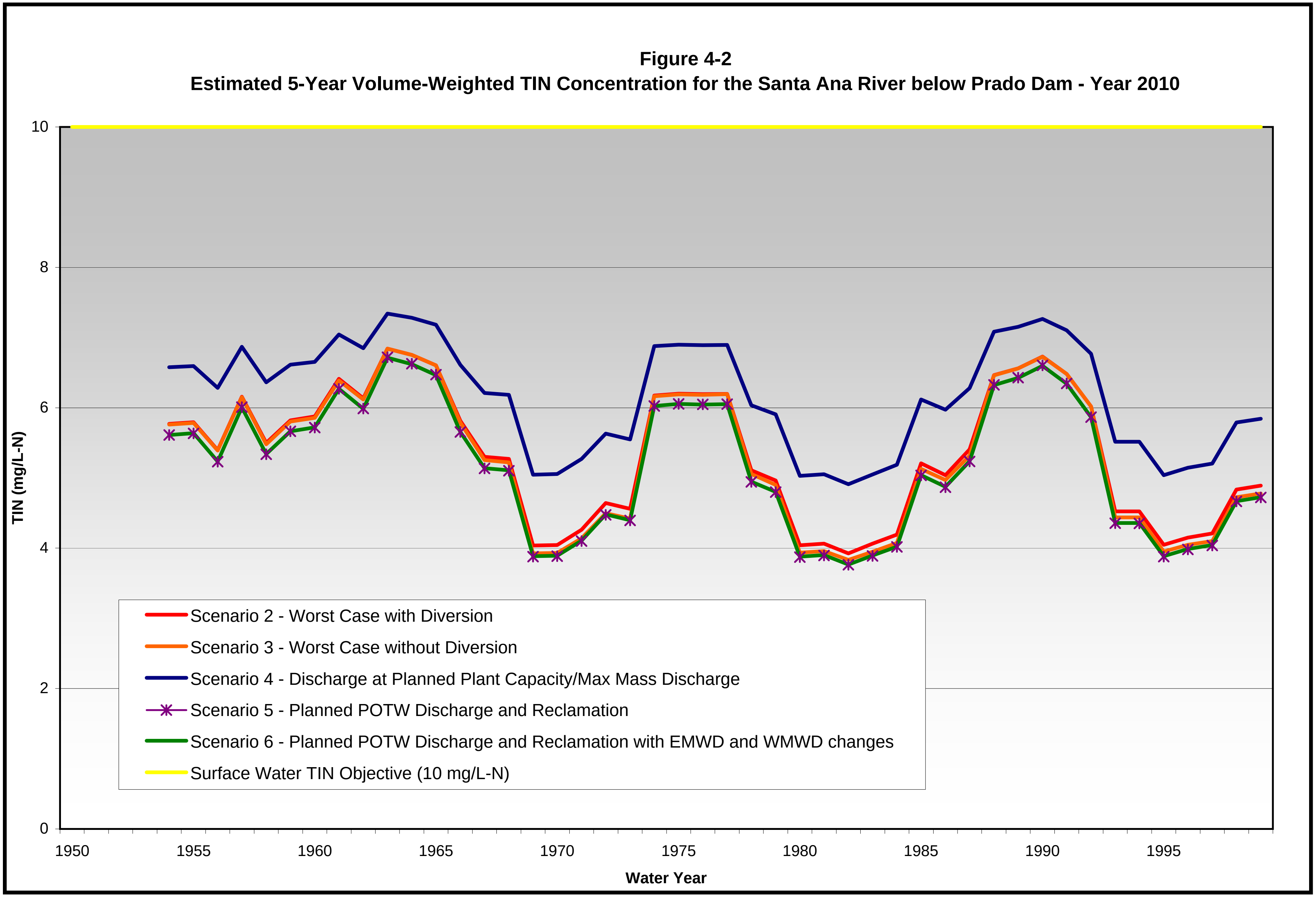

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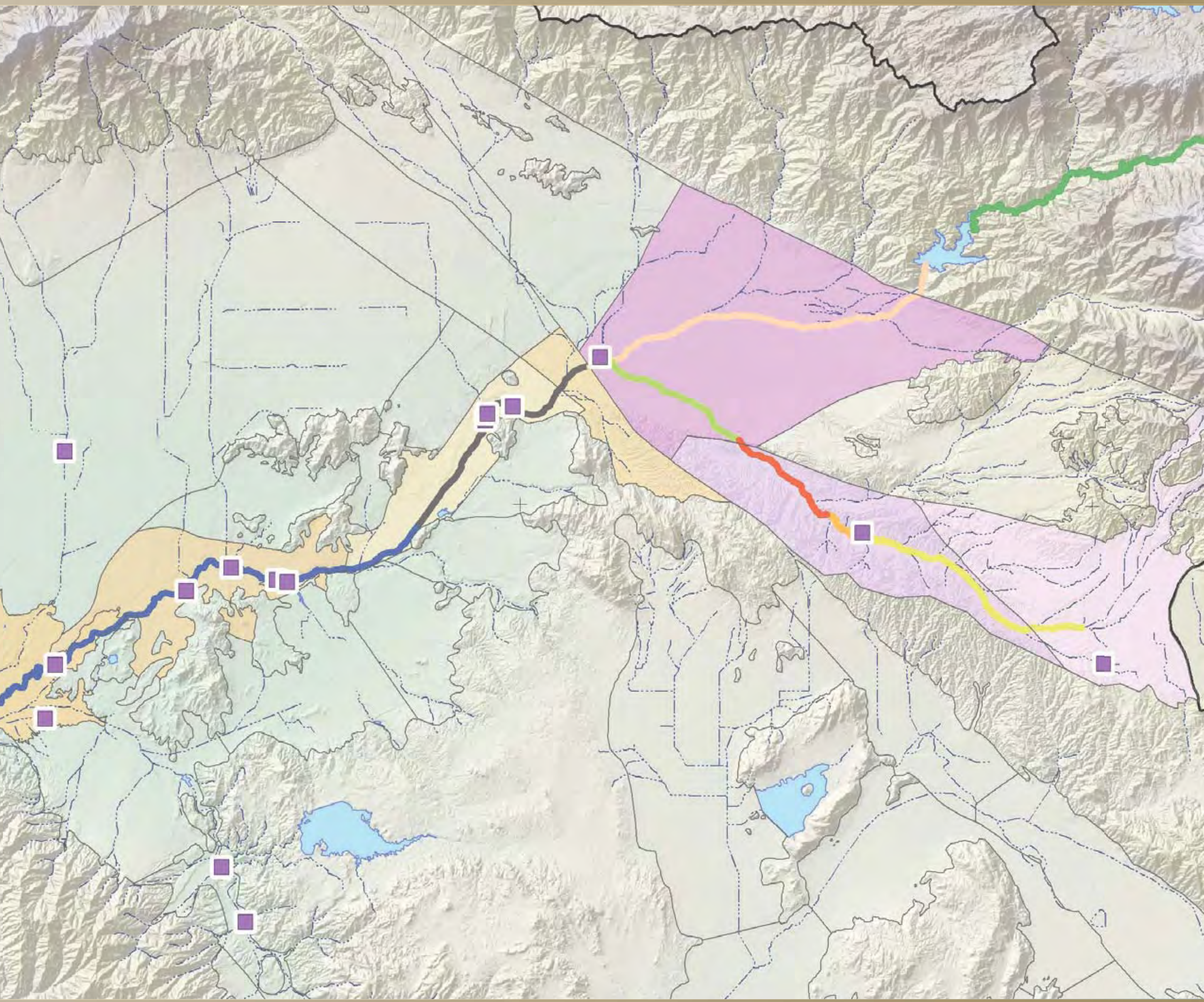

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